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Ecological Studies of Certain Natural Mortality Factors of the Sugarcane Borer, Diatraea Saccharalis (Fabricius) in Louisiana.

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ECOLOGICAL STUDIES OF CERTAIN NATURAL MORTALITY FACTORS OF THE SUGARCANE BORER, DIATRAEA SACCHARALIS (FABRICIUS) IN LOUISIANA

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ABSTRACT

Field experiments were conducted during 1966 and 1967 in the Bayou Sec area of Assumption Parish near Napoleonville, Louisiana to: (1) study the seasonal abundance of predator populations, (2) evaluate, quantitatively, the relative importance of these predators to the sugarcane borer by means of correlation between numbers of predators and the degree of egg and larval mortality of the borers, (3) obtain qualitative evidence of predation through frequent and widespread field observations, and (4) study the feeding behavior and habits of the predators concerned.

Predator populations differed significantly during the months of June, July, August and September. Both ant and spider populations reached peaks during August and September. Spider populations were generally higher than ant populations.

Average percent egg predation was higher during August and September than during June and July. Percent eggs destroyed by sucking predators was significantly higher than those destroyed by chewing predators. More predation was recorded during the night than during the day. Positive correlation coefficients were found between total numbers of predators, ants and spider populations, and percent egg predation. Spiders were found to be more closely associated with percent egg predation than ants.

Percent recovery of sugarcane borer larvae was significantly higher in July than in June. Numbers of predators and percentages

of hatchability had a more significant effect on percentages of larval recovery than numbers of sugarcane plants per stool.

Predators that were observed feeding on the different stages of sugarcane borer belong to the following taxa of arthropods: Formicidae, Carabidae, Forficulidae, Elateridae, Chrysopidae, and Araneida.

INTRODUCTION

Past efforts to utilize biological organisms for control of insect pests have often overemphasized the importance of parasites, especially introduced species and have ignored or minimized the value of native predator species. During the past 40 years, considerable effort has been devoted to introduced parasites and to laboratory propagation and release of *Trichogramma* spp. for control of the sugarcane borer, *Diatraea saccharalis* (F.) in Louisiana. These programs contributed little or nothing to economic control of the sugarcane borer and were discontinued in 1959.

Predators are difficult to study. They are usually omnivorous and leave little or no evidence of the species or number of specimens consumed. Many are primarily active at night and their activity is disrupted when light is utilized for observation purposes. In undertaking a study of the predators that attack the sugarcane borer, there is a great need for adequate methods to measure predator effect quantitatively. Yet it is difficult to develop such methodology due to the nature and complexity of the many mortality factors involved.

Studies reported in this dissertation were undertaken to: (1) study the seasonal abundance of predator populations, (2) evaluate, quantitatively, the relative importance of these predators to the sugarcane borer by means of correlation between numbers of predators and the degree of egg and larval mortality of the borer, (3) obtain qualitative evidence of predation through frequent and widespread field observations, and (4) study the feeding behavior and habits of the predators concerned.

REVIEW OF LITERATURE

For convenience, the contents of this review will be discussed in the following manner: the relative importance of the arthropod groups that are characteristically, or possibly, predaceous on sugarcane borer eggs, larvae, pupae, or adults as well as on other related pest species; and the effects of insecticides on populations of these predators with special reference to the ground-inhabiting species.

The Relative Importance of Natural Enemies

Ants, earwigs, ground beetles, and spiders are repeatedly recorded in the literature as possible predators of the sugarcane borer, *Diatraea saccharalis* (F.). Some other groups of arthropods are mentioned as preying on one stage or another, e.g., wireworms, lady-beetles, mites, soldier beetles, and chrysopids.

Formicidae

The importance of ants as predators of sugarcane insect pests is greatly underestimated. Stubbs and Morgan (1902) observed two unidentified species of ants attacking the eggs and moths of the sugarcane borer, *D. saccharalis*. Holloway et al. (1928) reported that the Argentine ant, *Iridomyrmex humilis* (Mayr) had been observed feeding occasionally on eggs that had been previously parasitized by the parasite, *Trichogramma minutum* Riley, and also on larvae and pupae that had been injured. They believed that ants caused more damage than benefit by husbanding mealybug populations.

Plank (1929) stated that the ants, Monomorium floricola Jerd., Solenopsis corticalis vigula Forel., and Prenolepis sp. were inhabiting tunnels made by the borer and feeding on borer larvae. Wolcott and Mortorell (1937) reported that the ant, Monomorium carbonarium ebeninum Forel, was observed feeding on fresh, parasitized, and hatched eggs of the sugarcane borer in Puerto Rico. They concluded that this ant would be a factor of importance in the natural control of the borer if it had a discriminating ability to choose nonparasitized eggs.

Tucker stated that 7 to 15 percent of Diatraea eggs were destroyed by the combined action of the acarid, Belaustium; green lacewing larvae, Chrysopa sp., immature forms of Psocids, and a black ant which had been found devouring a fresh egg mass. He further stated that larval mortality is not constant but varies with the time of the year, stage of cane growth, temperature, humidity, rainfall, wind velocity and variety of cane. He emphasized that the evaluation of various mortality factors must always be done on a comparable basis. He pointed out that early larval mortality may reach 90 percent, but it lessens late in the season and the survival rate is much higher, even up to 100 percent (1933, 1934, 1935, 1940). Clausen (1940) pointed out that 75 percent of the larvae, pupae, and adults of the southwestern corn borer, Diatraea (=Zeadiatraea) grandiosella Dyar, were destroyed by the ant, Solenopsis geminata diabola Whlr.

Ingram and Bynum (1941) concluded that the value of ants as predators was more than offset by their habits of husbanding aphids and mealybugs. Box (1953) listed the families Formicidae, Staphylinidae, Pentatomidae, and Reduviidae as predaceous upon any suitable insects in the cane fields. He stated that these insect predators feed indiscriminately on their prey.

According to Sweetman (1958), Paillot (1928) reported that ants of the genus Lasius removed all corn borers from large piles of corn stalks in portions of Europe. Guagliumi (1959) listed the ant Solenopsis geminata (F.) among the predators of Diatraea spp. in sugarcane fields in Venezuela.

In discussing the food habits of the imported fire-ant Solenopsis saevissima richteri Forel. Hays and Hays (1959) reported that this species is omnivorous; however, the primary dietary item was insects, both alive and dead. In the laboratory, when kept without food for several days, it fed on a few species of seedling plants.

Hadzistevic (1961) observed the ants Tetramorium caespitum (L.), Formica fusca glebaria (Nyl.), and Solenopsis fugax (Latr.) preying on the larvae and pupae of the stem borer Sesamia cretica (Led.).

Hensley et al. (1961) conducted studies to determine the relative importance of natural enemies in suppressing sugarcane borer populations in Louisiana. The following species of ants were found to be predaceous and some of them have been observed attacking the sugarcane borer: Iridomyrmex humilis Mayr., Paratrechina (=Nylanderia) sp. Pheidole dentata Mayr., Pheidole sp., Ponera opaciceps Mayr., Ponera trigona opacior Forel, Solenopsis saevissima richteri Forel, and Solenopsis xyloni McCook. Long and Hensley (unpublished data) conducted a survey of the sugarcane belt in Louisiana to determine the most common species of ants. They found nine genera representing 14 species. The species Paratrechina melanderi Whlr. was the most commonly occurring ant in Louisiana cane fields.

Negm and Hensley (1967) concluded that ants are among the more important natural control agents that determine the degree of infestation by the sugarcane borer. This conclusion was realized through direct observations of the feeding habits of ants in the field and negative correlation between number of ants and damage inflicted by the sugarcane borer.

Kutter (1963) indicated that red forest ants of the Formica rufa group are especially beneficial in forests because they destroy many harmful insects. Whitcomb and Bell (1964) observed workers of the ant Monomorium minimum (Buckley) killing a healthy fifth instar bollworm in Arkansas cotton fields. They also observed the ant Solenopsis geminata (F.) killing boll weevil adults and Paratrechina sp. removing bollworm eggs from the cotton plant.

Dermaptera

The majority of the earwig species are more or less predatory and none of them was studied carefully (Sweetman, 1958). According to Holloway et al. (1928), earwigs were found consuming larvae of Diatraea in Florida, and Wolcott (1917) observed them feeding on eggs of D. saccharalis in Texas. They indicated that it is unlikely that the work of the earwigs is of any importance in control because they attack the eggs that have been previously parasitized by Trichogramma minutum.

Plank (1929) observed the earwig, Prolabia unidentata (Palis.) feeding on the larvae and pupae of the sugarcane borer, D. saccharalis.

He also found that the earwigs, *Doru lineare* (Esch.) and *Anisolabis annulipes* (Luc.) feed only on the pupae. Tucker (1940) stated that earwigs were frequently observed in cane borer tunnels to a degree that warrant their inclusion as predators of sugarcane borer larvae. Ingram et al. (1941) reported that earwigs have been found feeding on both eggs and larvae of the sugarcane borer, *D. saccharalis*. Hensley et al. (1961) reported the earwigs *Euborellia annulipes* (Lucas) and *Labidura riparia* (Pallas) among the arthropods collected from sugarcane fields in Louisiana. The earwig *Spongiphora* sp. has been noted feeding upon leafhoppers on sugarcane in Australia (Clausen, 1940).

Carabidae

Guagliumi (1959) listed the carabids *Calosoma alternans* (F.) and *Leptotrachelus puncticollis* (Bates) as predators of the sugarcane borer, *D. saccharalis*, in Venezuela. Hensley et al. (1961) reported the carabids *Calosoma* sp., *Dicaelus* sp., *Feronia* sp., and *Scarites* sp. among an extensive list of the arthropods collected from Louisiana sugarcane fields.

Staphylinidae

Many species of rove beetles are predaceous, and a few species are parasitic. Some of the staphylinids are scavengers but they may feed on other insects in the decaying materials where they live. They have been observed to prey on dipterous, coleopterous, and lepidopterous larvae and pupae (Sweetman, 1958).

Hensley et al. (1961) included the rove beetles among a list of arthropods collected from sugarcane fields in Louisiana, but the genera were not recognized. Long (unpublished data) found that the most abundant species of staphylinids in the sugarcane fields at Franklin, Louisiana, were Philonthus alumnus (Er.) and Philonthus brunneus (Gr.).

Araneida

Regarding the feeding habits of spiders, Bilsing (1920) stated that there is no evidence that any species of spiders have a particular preference for their prey. Lovell (1915) reported that the crab spiders (Thomisidae) fed on certain species of Hymenoptera, Diptera, and Lepidoptera. Earwigs, Carabids, Cicindelids, and an araneid, Clubiona pacifica Banks, were included on the food list of the black widow spider, Latrodectus mactans (F.), by Exline and Hatch (1934).

According to Tucker (1940), spiders were the major predators of the sugarcane borer moth. He stated that the young larvae of D. saccharalis were captured by Attid and Agriopid spiders which frequent the cane leaves. Hensley et al. (1961) stated that twenty-three species of spiders were collected from pitfall traps located on several plantations in Louisiana sugarcane fields. These species had not previously been reported to occur in Louisiana and represent the following families: Agelenidae, Anyphaenidae, Clubionidae, Dysderidae, Epeiridae, Gnaphosidae, Linyphiidae, Lycosidae, Micryphantidae, Minetidae, Nesticidae, Oxypodidae, Pholcidae, Pisauridae, Salticidae, Tetragnthidae, Theriidae, and Thomisidae.

Negm and Hensley (1967) reported six new species of spiders in similar studies. Moreover, spiders were found to play a minor part in determining the degree of infestation by the sugarcane borer.

Evaluation of the influence of predation on the European corn borer *Ostrinia nubilalis* (Hbn.) has been done by Huber (1936); Bartholomai (1954); Chiang (1959); Conrad (1959); and Sparks et al. (1966).

Miscellaneous

The larvae of the soldier beetles *Chauliognathus marginatus* (F.) were observed feeding upon the sugarcane borer *D. saccharalis* (Stubbs and Morgan, 1902; Ingram and Bynum, 1941). A species of wireworm *Drasterius elegans* Fabricius has been reported to be predaceous on the sugarcane borer (Stubbs and Morgan, 1902; Plank, 1929). The acarid, *Belaustium* sp. was observed by Tucker (1940) sucking the contents of the egg masses of *D. saccharalis*. *Chrysopa* sp. larvae were observed devouring a fresh *Diatraea* egg mass. The coccinellids *Coleomegilla maculata* De G., *Cycloneda antillensis* Crotch, *C. sanguinea* L., and *Scymnus* spp. were reported by Guagliumi (1959) as predators of *D. saccharalis* in Venezuela.

Hensley et al. (1961) reported the presence of the Cantharids *Belotus* sp., and *Chauliognathus marginatus* (F.); the Coccinellids, *Scymnus* (*Diomus*) *terminatus* (Say); the Elaterids, *Colaulon rectangularis* (Say), *Conoderus bellus* (Say), *C. melliculus rudis* Brown, *Neotrichophorus carolinensis* (Schaeffer); the Lampyrid, *Photuris* sp.; and the Melyrid, *Collops* sp. in sugarcane fields in south Louisiana.

Effects of Insecticides on Soil-Inhabiting Predaceous Arthropods

Ingram et al. (1950) stated that there was no evidence that chlordane, BHC (0.2% gamma). DDT, and toxaphene were upsetting the natural balance of soil fauna in sugarcane fields in Louisiana. Mathes et al. (1956) stated that there was a danger in the use of chlordane, endrin, isodrin, and dieldrin for controlling soil insects because they killed some of the natural enemies of the sugarcane borer such as earwigs and ants.

Long et al. (1958) and Hensley et al. (1961) found an increase in sugarcane damage by the sugarcane borer accompanying the use of two pounds actual heptachlor per acre for imported fire-ant control and concluded that the increase in damage was due to the suppression of the natural enemies of the borer. According to Hensley et al. (1961), the total numbers of ants collected from pitfall traps indicated reductions of 78 and 53 percent, respectively, in endrin and ryania-treated plots when four applications of these insecticides were used for sugarcane borer control. Negm and Hensley (1967) stated that soil application of heptachlor had significantly more destructive effects on ground-inhabiting predaceous arthropods, especially on ants, than endrin or azinphosmethyl (Guthion) in sugarcane fields in Louisiana. No difference in spider populations was recorded in plots treated with either endrin or azinphosmethyl. The latter was found to have the least drastic effects on predator populations, particularly ants.

In a study to determine the toxicity of aerosols containing DDT, derris extractives, and nicotine to several pests attacking truck crops, Smith et al. (1945) found that DDT aerosols had only a temporary effect on the populations of the predators. They stated that the following species of ground beetles were susceptible to DDT aerosols: Dicaelus dilatatus (Say); Harpalus pennsylvanicus (Deg.); H. compar Le Conte, and H. faunus Say.

During a study to determine the species and numbers of carabids in the soil of a peach orchard that had received DDT foliar sprays for several years, Herne (1963) found that small numbers of the carabid, Pterostichus melanarius (Ill.) were caught in plots where foliar sprays of DDT had been used recently, but large and varied populations of carabids persisted in all plots despite repeated applications of DDT for a period of 10 years. Whitcomb and Bell (1964) stated that a carabid, Calosoma sp., completely disappeared after application of small amounts of chlorinated hydrocarbon insecticides, in contrast to Pterostichus chalcites Say which persisted in spite of repeated use of these insecticides in cotton fields.

Schread (1948) reported that the ant Lasius niger americanus was completely eliminated by using four ounces of 50% chlordane wettable powder to 1000 square feet of turf. According to Stephen (1956), the ant, Formica fusca, and the earwig, Forficula auricularia (L.), were controlled by using heptachlor dust concentrations from 1 to 25 percent.

Surface applications of DDT and BHC on grass land would not penetrate the soil in sufficient quantities to induce statistically significant responses in the underlying insect populations (Sheals, 1958). He found that staphylinids were highly susceptible to DDT in the laboratory.

MacPhee and Sanford (1954) studied the influence of spray programs on some beneficial arthropods of apple orchards in Nova Scotia. They concluded that DDT, parathion, and sulphur have drastic effects on natural enemies. The predator and parasite taxa studied were Thysanoptera, Anthocoridae, Coccinellidae, Acarina, and parasitic Hymenoptera. In 1961, they found that DDT, diazinon, guthion, malathion, parathion, and trithion were relatively harmless to several beneficial species but harmful to others.

Ripper (1959) reviewed the effects of pesticides on balance of arthropod populations. He concluded that DDT and parathion appear to be detrimental to predaceous arthropod populations. Hoffman et al. (1948, 1949) studied the fluctuations of insect populations associated with aerial applications of DDT to forests. They found that DDT at the rate of 2 pounds per acre did not affect staphylinid or carabid populations. All spiders studied fared well, except phalangiids, which were almost eliminated. Use of DDT-oil solution, at the rate of 4 and 5 pounds of DDT per acre, did not seriously affect many of the beneficial scavengers and predators. The number of ants was diminished only during the first week after application.

Methods for evaluating the efficiency of natural enemies of certain pests have been published by DeBach (1946), and DeBach et al. (1949, 1951). Studies on population dynamics and evaluation of natural mortality factors by means of life tables have been published by Leopold (1939); Deevey (1947); Morris and Miller (1954); Morris et al. (1956); Morris (1957); and Harcourt and LeRoux (1967). Papers that deal with the different interpretation of mortality factors have been published by Thompson (1928); Nicholson (1933); Bodenheimer (1938); Varley (1947); and Bess (1945).

MATERIALS AND METHODS

Description of Study Area

These studies were undertaken in the Bayou Sec area of Assumption Parish near Napoleonville, Louisiana. This area is ideally suited for studies of predators of the sugarcane borer. Insecticides have never been used for control of the sugarcane borer on sugarcane because of the possibility of contaminating other crops or waterways with residues. Infestation records show that the sugarcane crop is less severely damaged by the sugarcane borer here than on nontreated cane in many other areas of Louisiana, especially where insecticides are used extensively for control.

Individual farms average less than 40 acres in size and many are partially surrounded by woodlands, pastures and waterways. Fields of sugarcane are usually small, averaging less than 10 acres in size and are intermingled with fields of vegetables and grain crops. The particular field in which these studies were carried out was located on Hymel Brothers Farm adjacent to Bayou Sec.

The experimental method of evaluation involved paired comparisons of plots in which natural enemies were present with plots in which they were excluded. The experiment consisted of 4 blocks each subdivided into 2-1/2 acre plots that were 72 feet wide (12 rows) by 48 feet long.

Four plots were treated with 10% granules heptachlor to exclude soil-inhabiting predaceous arthropods and the other 4 plots were left nontreated. Four applications of heptachlor granules were made at the rate of 4.0 lbs/acre/application at approximately monthly intervals between applications.

The insecticide was weighed and then shaken on the soil surface between the rows from one-gallon tin cans as the operator walked through the plots. Insecticide was dispensed through perforations in the bottom of the cans which were always held near ground level to avoid contaminating stalks of sugarcane. These insecticide applications were used to suppress predator populations in the treated plots and not for direct control of the sugarcane borer.

Sampling Techniques

Predator populations

Several methods were used for sampling predators in the field. Pitfall traps were used to collect species that frequent the soil surface and to give qualitative records of the predator groups and to detect changes in predator populations during the growing season. One pitfall trap was placed in the center of each plot. Each trap was prepared by imbedding a 1-quart wide-mouth glass freezer jar in the soil so that the top was level with the soil surface. A galvanized metal disc 7 inches in diameter supported on a metal tripod was placed over the jar to exclude rain and debris. The tripod was lowered into the soil until the disc was about 1 in. above the top of the jar. The jars were partially filled with 95% ethyl alcohol over which a thin layer of kerosene was poured to prevent evaporation.

Specimens were removed from traps weekly and transferred to 95% ethyl alcohol after being washed several times in acetone. Arthropod predators were sorted and identified to family and whenever possible to species. The numbers of predators in each family, including ants, spiders and ground beetles, were recorded by plots. These traps were operated continuously from June through late September each year.

Particular emphasis was placed on careful examination of individual sugarcane plants for presence of predatory arthropods. Samples consisting of 10, 20, or 50 plants were chosen at various points in the field for examination. The area around each plant was first scanned and then the plant was examined leaf by leaf. Predators that frequent the sugarcane leaves and stems were collected with an aspirator.

Nocturnal collections of predators were made with the aid of a 6 volt flashlight. Collections were sometimes made with a 15-in. California type net especially during the early part of the growing season when the sugarcane plants were small, but this method was discontinued later in the season.

Sugarcane borer damage surveys

A random sample consisting of 20 stalks was taken from the middle 3 rows of each plot at bi-weekly intervals. This sample was always obtained from the immediate vicinity of the pitfall trap in the center of each plot. The percentage of plants infested by sugarcane borer larvae was determined by examining the leaf sheaths and the internodes of each of these plants for the presence of live borers. Only those containing live borers were considered infested. At harvest time, a random sample consisting of 50 stalks was obtained from each plot by selecting a sub-sample of 10 stalks from each of the 5 middle rows. The distance between sub-samples was 30 feet.

Several attempts were made to determine the percentage of plants that contained borer feeding signs without larvae present in the leaf sheaths. This provided an indication of the degree of mortality among the larvae and its correlation with the presence of certain larval predators.

Evaluation of Natural Mortality Factors

For the purpose of these studies egg masses were obtained from laboratory reared moths. Cylindrical 1-gallon paper cartons with tops replaced with those made from 16 mesh plastic screen were used as emergence and oviposition cages. Each cage was lined with waxed paper and contained a 2-3 in. layer of vermiculite that was moistened every 3 days. A piece of waxed paper (6 in. x 8 in.) folded to provide a corrugated effect was placed inside. Moths usually deposited more eggs on this paper than on the lining. Pupae, in small containers shaped from aluminum foil, were placed in each cage. From 20 to 30 pairs of moths were maintained in a cage continuously by replacing pupae as needed. These cages were kept in rearing cabinets at a temperature of 25°C with a 14-hour photoperiod.

The waxed paper on which egg masses had been deposited was removed from the oviposition cages within 12 hours after egg deposition. Small triangles each containing a single egg mass visually estimated to range in number of eggs from 10 to 20 were cut from the waxed paper. Actual counts of eggs were not made.

Study of egg mortality

Egg masses that ranged in age from 12 to 14 hours were used in this study in order to permit at least 3 days of direct observation in the field before hatching occurred. One egg mass was placed on each of 5 different sugarcane stools located on each of the 2 middle rows of each plot. These stools were approximately 5 feet apart. Egg masses were fixed on the lower and/or upper part of the midrib of the leaf near the leaf sheaths. Straight pins were used to hold the egg mass in position.

Numbers of egg masses eaten by arthropod predators were recorded after 12, 24, 48 and 72 hours in order to obtain records of percent predation. Egg masses left on the plants were then removed to prevent hatching and to study the nature and type of feeding symptoms by the different predator groups. Comparisons of percent predation between periods of daylight and darkness as well as comparisons between percent predation by sucking and chewing predators were also made. These studies were repeated every week from June until September of each year.

Study of larval mortality and behavior

Larval mortality and behavior were studied by artificially infesting isolated sugarcane stools in treated and nontreated plots. Twenty stools comprised of 5 stools from each of the 4 center rows were infested in each of 2 treated and nontreated plots. Stools between those isolated for study were uprooted and removed to prevent larval migration among stools under study. Each stool was infested with a known number of borer larvae. The following procedure was used to determine the exact number of larvae placed on each stool. The number of eggs per mass was determined in the laboratory and each egg mass was placed in a separate vial and plugged with a piece of cotton. Each vial was given a serial number with the corresponding number of eggs per mass. Individual stools were infested with these egg masses at a rate of one egg mass per stool and were allowed to remain on the plant until most of the eggs hatched. The egg mass from each stool was then removed and returned to the same vial. The number of larvae that hatched was determined by deducting the number of eggs that failed to hatch and remained on the waxed paper from the total number per mass.

To determine the percent recovery of the sugarcane borer larvae, 5 stools were randomly selected weekly from each plot and carefully dissected and examined. The number of live borers and the different instars were recorded in each plot. The number of sugarcane stalks per stool was also recorded. These studies were conducted during June and July of each year.

Attempts were made to study the behavior of 1st instar larvae by placing egg masses in the black-head stage of development on plants and observing the larvae during and after hatching.

Field and Laboratory Observations on Predation

Several hours were spent in the field observing the feeding behavior and habits of the predators under study. More emphasis was placed on observing these predators at night since most were nocturnal in habit. Eight observations at night were made at 2-week intervals during the growing season. These observations were made at different hours ranging from 8:00 p.m. to 1:30 a.m. to determine predatory species, their symptoms of feeding and frequency of feeding.

Predation records were taken by carefully examining infested plants, especially behind the leaf sheaths, for presence of predators feeding on sugarcane borer larvae. Predation on sugarcane borer egg masses was investigated by pinning egg masses to sugarcane leaves and observing them during daylight and darkness. Predation of sugarcane borer eggs and larvae by certain predators was also observed in the laboratory by confining freshly deposited egg masses and different instars of the borer in large vials with several individuals of one predator species.

Statistical Analyses

The significance between treated and nontreated plots on different dates was determined by the F-test. These data were analyzed as a dates x treatments factorial experiment.

Simple correlation coefficients were computed between numbers of predators, ants or spiders and percent egg predation. The corresponding partial regression coefficients were also computed. Coefficients of partial regressions of percent hatchability, numbers of predators or number of plants per clone on percent larval recovery were computed by multiple correlation analysis.

One abbreviation and 2 symbols are used without explanation in some tables of the results. The abbreviation ns, indicates that the difference between means was not significant. Single asterisk (*) and double asterisks (**) indicate statistical significance at the 5% and 1% levels, respectively.

RESULTS

The genera and species of arthropod predators that have been identified from pitfall trap collections during these studies, as well as other predators collected from sugarcane plants, are listed in Table I. The arthropod groups which were collected in large numbers from the traps were ants (Formicidae) and spiders (Araneida). These two groups of predators constituted the major part of the total predator complex that was consistently caught in the traps. Other groups of predators, i.e. earwigs (Dermaptera), click beetles (Elateridae), and ground beetles (Carabidae) were collected only in small numbers.

Seasonal Abundance of Predator Populations

Total predator complex

Table II shows the total numbers of predators that were caught in the traps from June to September in 1966 and in 1967 in both heptachlor-treated and nontreated plots. Data in this table are illustrated graphically in Figure 1. Statistical analysis of the results showed that soil treatment with heptachlor granules significantly (1% level of probability) reduced predator populations in comparison with the nontreated plots in 1966. However, the difference of predator populations between treatments was not significant in 1967. Predator populations differed significantly (1% level) during the months of June, July, August, and September. Predator populations were relatively low during June in the nontreated plots and increased during July, August, and September. The highest numbers of predators were recorded in September.

Table I. Species of predaceous arthropods collected from pitfall traps and from sugarcane plants in a sugarcane field, Napoleonville, Louisiana, 1966 and 1967.

Predators collected from pitfall traps

Hymenoptera

Formicidae

Solenopsis saevissima richteri Forel*
Monomorium sp.

Coleoptera

Carabidae

Scarites sp.
Agonum (Circinalia) punctiformis (Say)
Calosoma scrutator (Fabricius)
Calosoma alternans sayi Dejean
Galeritula sp.
Pterostichus chalcites Say
Chlaenius erythropus Germar

Elateridae

Conoderus vespertinus (Fabricius)*
C. rudis Brown
Drasterius scutellatus Schffr.*

Dermaptera

Forficulidae

Doru aculeatum (Scudder)*

Labiduridae

Anisolabis annulipes (Lucas)*
Labidura riparia (Pallas)

Araneida

Agelenidae

Agelenopsis emertoni Chamberline and Ivie
Wadotes hybridus (Emerton)

Table I. Continued

Micryphantidae

Eperigone tridentata Emerton*
Erigone autumnalis Emerton

Lycosidae

Lycosa modesta (Keyserling)
Lycosa helluo Walck.
Pardosa distincta Hentz
Pardosa milvina (Hentz)*
Pardosa moesta Banks
Pardosa saxitilis Hentz
Pirata sylvanus Chamberline and Ivie

Epeiridae

Singa variabilis Emerton*
Larinia directa Hentz

Theridiidae

Achaearanea index Chamberline and Ivie*
Coleosoma acutiventer Keyserling*
Paratheridula quadrimaculatus Banks*

Nesticidae

Nesticus pallidus Emerton*

Clubionidae

Castianeira descripta (Hentz)
Clubiona abotti L. Koch*

Tetragnathidae

Pachygnatha autumnalis Keyserling
Leucauge ventusa (Walckaenaer)*

Salticidae

Habronattus coronatus (Hentz)*

Table I. Continued

Predators collected from sugarcane plants

Elateridae

Conoderus vespertinus (Fab.) - Larvae and adults
C. rudis Brown - adults
Drasterius scutellatus Schffr. - adults

Carabidae

Leptotrachelus dorsalis (Fab.)*
Chlaenius (Anomoglossus) pusillus Say*
Harpalus sp. - Larvae

Chrysopidae

Chrysopa sp. - Larvae

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*Collected from sugarcane plants and pitfall traps.

Table II. Total numbers of predators collected in pitfall traps in a sugarcane field in heptachlor-treated and nontreated plots. Napoleonville, Louisiana, 1966 and 1967.[1]

Month	Treated		Nontreated	
	1966	1967	1966	1967
June	67.0	26.0	66.0	14.0
July	63.0	60.0	122.0	89.0
August	85.0	78.0	197.0	113.0
September	142.5	131.0	213.0	155.0
Average	89.3	73.7	149.5	92.8

[1]Figures are totals of 4 counts per month. Every count is a total of 4 replicates. Data are shown in Tables XVII and XVIII in the appendix, resepctively.

1966: Treatments (**); Months (**); Treatments x Months (ns).
1967: Treatments (ns); Months (**); Treatments x Months (ns).

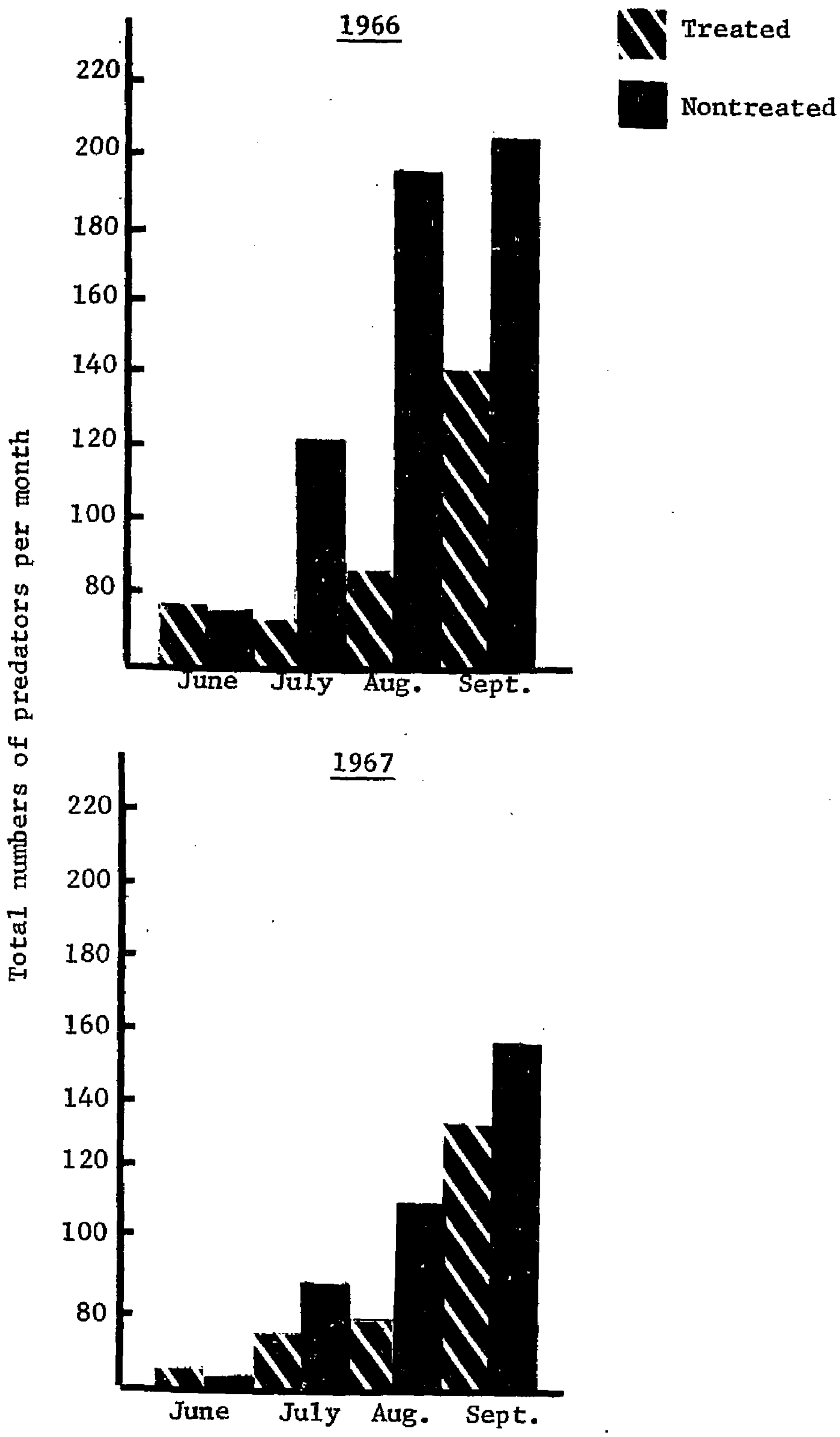

Figure 1. Total number of predators collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.

The same population trend was recorded in the treated plots, although the rate of increase in numbers of predators was slower than in the nontreated plots. Predator populations were generally higher in 1966 than in 1967.

Ant and spider populations

Table III shows monthly abundance of both ant and spider populations during 1966 and 1967 in both treated and nontreated plots. Data in this table are illustrated graphically in Figure 2. Differences of ant populations between treatments were found to be significant in 1966 and 1967. Ant populations were significantly higher in nontreated than treated plots. However, difference of spider populations between treatments was significant in 1966 but not significant in 1967. Ant and spider populations were found to vary significantly from month to month and both populations reached peaks during August and September. Spider populations were found to be significantly higher than ant populations in treated and nontreated plots. Statistical analysis of the total numbers of spiders in 1966 showed a highly significant interaction existed between treatment and months.

Egg Mortality

Seasonal trend of percent egg mortality

Table IV shows a summary of average percent egg predation from June to September in 1966 and 1967 in both treated and nontreated plots. Data in this table are illustrated graphically in Figure 3. A highly significant difference was found in the percentage of egg predation between treatments. Percent egg predation was significantly

Table III. Total numbers of ants and spiders collected in pitfall traps in a sugarcane field in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.[1]

Month/year	Treated Ants	Treated Spiders	Nontreated Ants	Nontreated Spiders
June				
1966	17.0	49.0	16.0	45.0
1967	6.0	17.0	4.0	8.0
July				
1966	8.0	48.0	12.0	100.0
1967	10.0	46.0	30.0	51.0
August				
1966	29.0	51.0	51.0	139.0
1967	17.0	58.0	36.0	69.0
September				
1966	57.0	74.0	76.0	124.0
1967	48.0	64.0	71.0	71.0
Average				
1966	27.8	55.5	38.8	102.0
1967	20.3	46.3	35.3	49.8

[1]Figures are totals of 4 counts per month. Every count is a total of 4 replicates. Data are shown in Tables XIX, XX for ants, XXI, XXII for spiders, respectively.

Ants - 1966: Treatments (*); Months (**); Treatments x Months (ns).
1967: Treatments (**); Months (**); Treatments x Months (ns).

Spiders-1966: Treatments (**); Months (**); Treatments x Months (**).
1967: Treatments (ns); Months (**); Treatments x Months (ns).

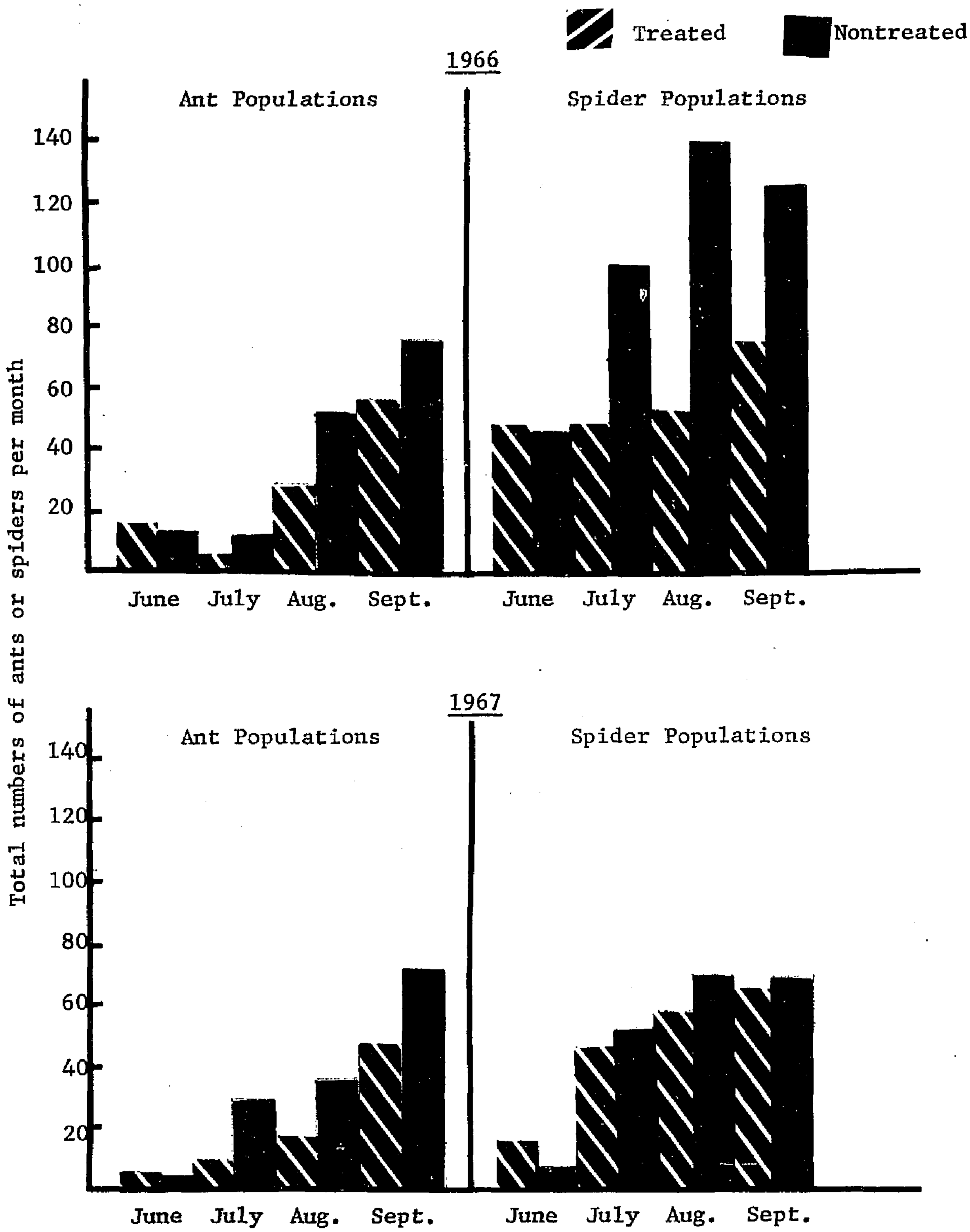

Figure 2. Comparison between ant and spider populations in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.

Table IV. Summary of average percent predation of sugarcane borer egg masses destroyed by arthropod predators in heptachlor-treated and nontreated plots. Napoleonville, Louisiana, 1966 and 1967.[1]

	Treated		Nontreated	
Month	1966	1967	1966	1967
June	25.6	15.6	45.6	30.0
July	34.4	28.8	61.3	40.0
August	43.8	36.3	71.9	60.0
September	43.1	27.5	61.3	57.5
Average	36.7	27.1	60.0	46.9

[1]Figures are means of 4 counts per month. Each count represents a mean of 4 replicates. Original data are shown in Tables XXIII and XXIV in the appendix, respectively.

1966: Treatments (**); Months (**); Treatments x Months (ns).
1967: Treatments (**); Months (**); Treatments x Months (**).

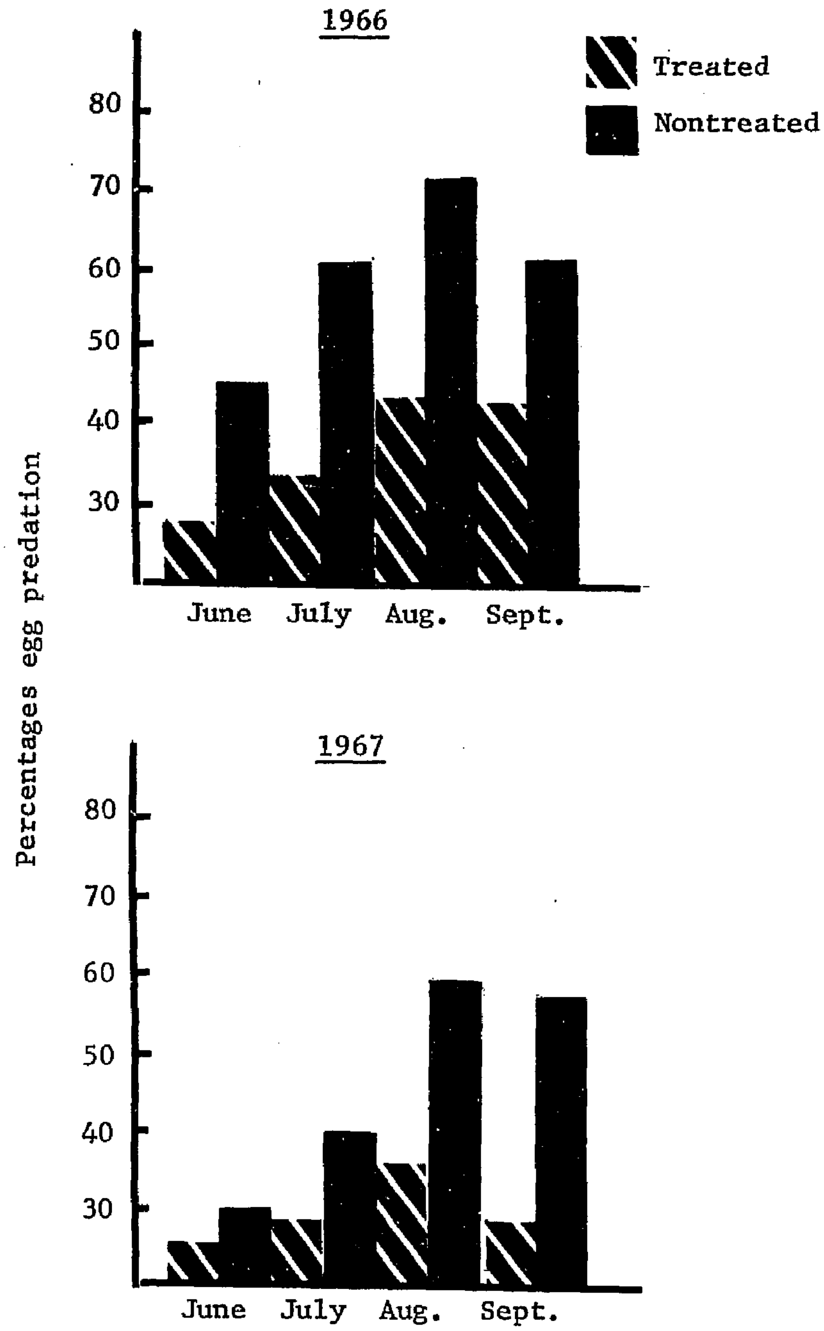

Figure 3. Average percentages egg predation in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.

higher in nontreated than in treated plots. Moreover, percent predation differed significantly from month to month and was relatively low during June.

The average percent predation during August and September was higher than in June and July. These results were similar in 1966 and in 1967. In 1967, a highly significant interaction was found between treatments and months.

Relative importance of sucking and chewing predators

Comparison between percent eggs destroyed by sucking and chewing predators was used to determine the relative importance of each group as natural control agents of the sugarcane borer eggs. Tables V and VI show a comparison between percent predation of sucking and chewing predators for 1966 and 1967, respectively. Data in these tables are illustrated graphically in Figure 4. Percent eggs destroyed by sucking predators was significantly higher than percent eggs destroyed by chewing predators. On the average, significantly higher predation was recorded by both groups of predators during August and September than during June and July.

Percent egg predation during daylight and darkness

Table VII shows a comparison between percent predation during day and night in both treated and nontreated plots. Data in this table are illustrated graphically in Figure 5. Percent egg predation was significantly higher during darkness than during daylight hours. No significant difference was found in percent egg predation that was recorded during daylight hours among months. During July, August, and September, some predation was recorded during daylight hours.

Table V. Comparison between percent egg masses destroyed by sucking and chewing predators in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.[1]

	Treated		Nontreated	
	Sucking	Chewing	Sucking	Chewing
Month	Predators		Predators	
June	22.5	3.1	38.1	7.5
July	18.8	15.6	35.0	26.3
August	25.6	18.2	50.0	21.9
September	28.7	14.4	33.8	27.5
Average	23.9	12.8	39.2	20.8

Table VI. Comparison between percent egg masses destroyed by sucking and chewing predators in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1967.[1]

	Treated		Nontreated	
	Sucking	Chewing	Sucking	Chewing
Month	Predators		Predators	
June	8.8	6.8	21.3	8.7
July	18.2	10.6	28.7	11.3
August	22:5	13.8	43.7	16.3
September	15.6	11.9	42.5	15.0
Average	16.3	10.8	34.1	12.8

[1]Figures are averages of 4 counts per month. Each count represents an average of 4 replicates. Data are shown in Tables XXV and XXVI in the appendix, respectively.

1966:
1967: Sucking vs chewing predators (*).

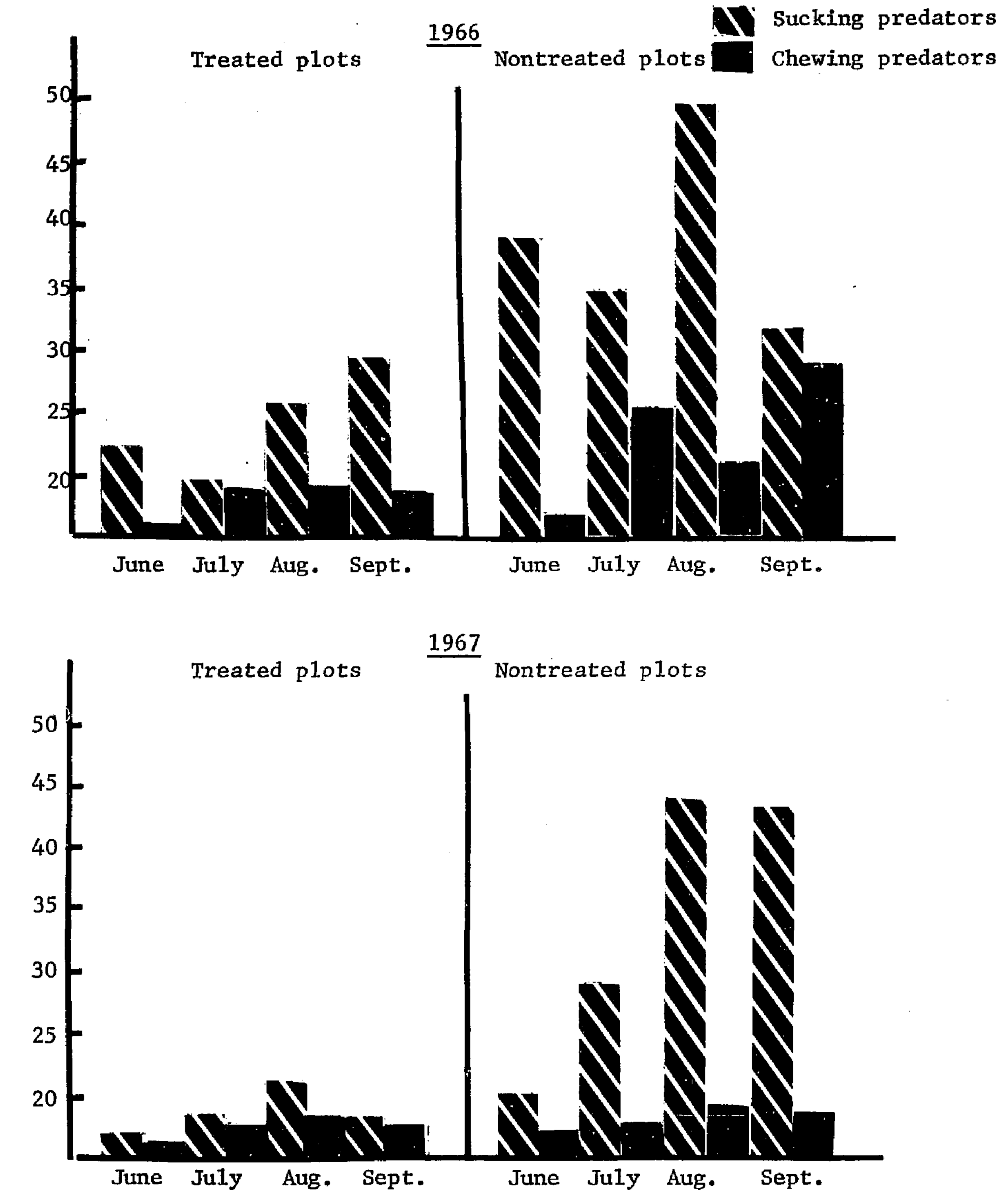

Figure 4. Comparison of percentages of egg predation by sucking and chewing predators in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.

Table VII. Average percent predation of the sugarcane borer egg masses during day and night. Napoleonville, Louisiana, 1966.[1]

	Treated		Nontreated	
	Period of exposure (12 hrs.)			
Month	Daylight	Darkness	Daylight	Darkness
June	0.0	11.3	0.0	12.6
July	1.3	9.3	6.9	7.5
August	2.5	12.5	0.0	9.5
September	5.0	10.6	4.3	19.9
Average	2.2	10.9	2.8	12.4

[1]Figures are means of 4 counts per month. Each count represents a mean of 4 replicates. Data are shown in Table XXVII in the appendix.

Daylight vs darkness (**).

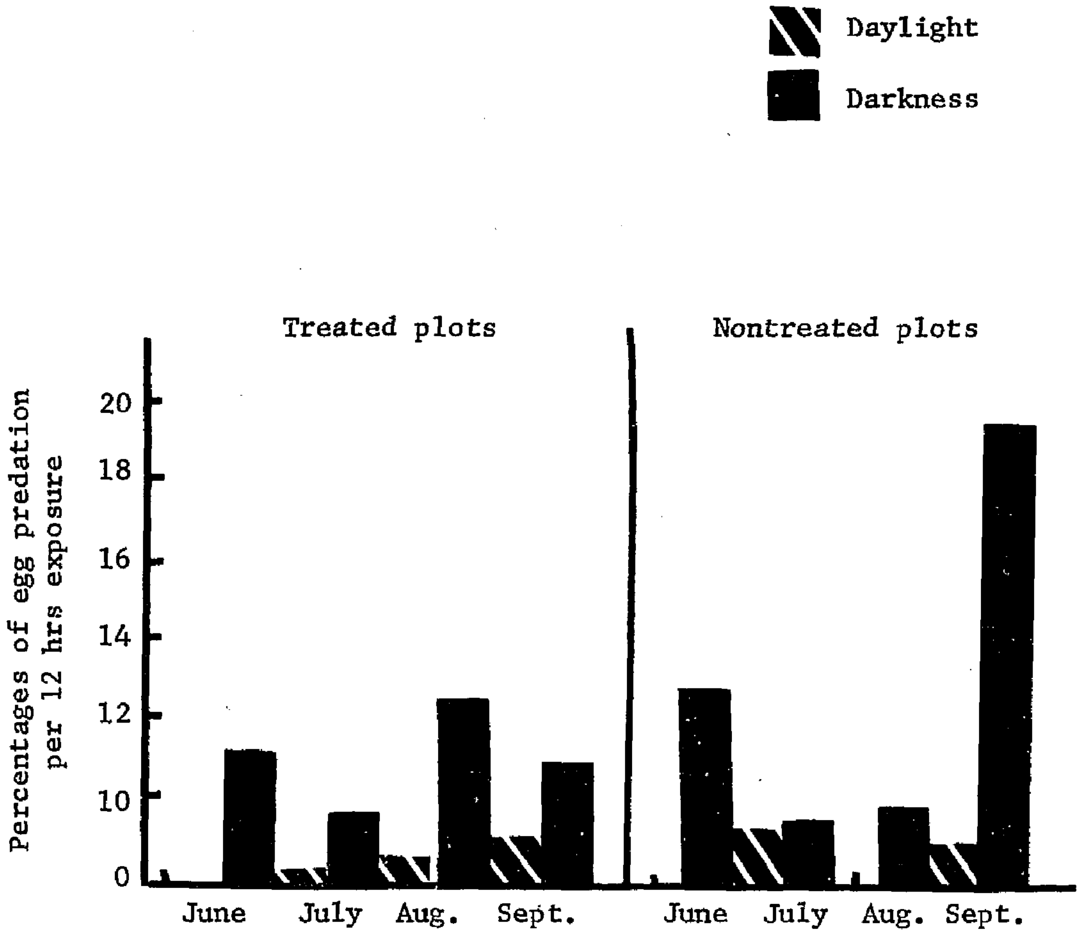

Figure 5. Averages of percentages of egg predation during daylight and darkness hours in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.

Correlation between Numbers of Predators and Percent Egg Predation

Simple correlation coefficients between total numbers of predator, ant or spider populations, and percent egg predation were computed separately. The corresponding regression coefficients were also computed. Tables VIII and IX show summaries of the data and the results of the statistical analysis for 1966 and 1967, respectively. Two correlation coefficients were computed for each criterion, the first represents 1966 and the second represents 1967.

Generally, positive correlation coefficients were found between predator groups and percent egg predation. The simple correlation coefficients ($r = 0.432$ and 0.419) were found to exist between the total numbers of predators and percent egg predation and they were significant at the 5% level of probability. A significant correlation coefficient was also found between numbers of spiders and percent egg predation ($r = 0.408$ and 0.398). However, the correlation coefficients ($r = 0.353$ and 0.328) between numbers of ants and percent egg predation were not significant.

Coefficients of partial regression of percent egg predation on total numbers of predators or numbers of spiders were highly significant ($b = 0.234$, 0.251, 0.277, 0.374, respectively). Coefficients of partial regression of percent egg predation on numbers of ants were found to be significant ($b = 0.441$ and 0.450). Further comparison between the simple correlation coefficients of spiders and ants showed that spider populations were more closely associated with percent egg predation than ant populations.

Table VIII. Average numbers of egg masses destroyed, total numbers of predators, and numbers of ants and spiders caught in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.

	Treated		Nontreated	
	1966	1967	1966	1967
No. of egg masses[a] destroyed	3.5	2.7	6.0	4.7
Predator complex[b]	5.6	4.6	9.6	5.6
Ant populations	1.6	1.3	2.5	2.2
Spider populations	3.7	2.9	6.5	3.1

[a]Average number per week per 4 replicates.
[b]Average number per trap per week.

Table IX. Summary of correlation coefficients and the corresponding partial regression coefficients between numbers of egg masses destroyed and numbers of predator complex, ant or spider populations, 1966 and 1967.[1]

	Number of egg masses destroyed			
	Simple correlation coefficient (r)		Partial regression coefficient (b)	
Arthropod groups (no. of specimens)	1966	1967	1966	1967
Predator complex	0.432*	0.419*	0.234**	0.251*
Ant populations	0.353ns	0.328ns	0.441*	0.450*
Spider populations	0.408*	0.398*	0.277**	0.374*

[1]Computations were based on data in Tables XXVIII and XXIX in the appendix, respectively.

Feeding Behavior and Habits of Egg Predators

The genera and species of arthropod predators that were observed feeding on eggs as well as on other stages of the sugarcane borer are listed in Table X. Predators that feed on the eggs in the field belonged to the following taxa of arthropods: Formicidae, Carabidae, Elateridae, Forficulidae, Chrysopidae, and Araneida. The following species of arthropod predators were observed feeding on the eggs of the sugarcane borer: *Solenopsis saevissima richteri* Forel, *Leptotrachelus dorsalis* (Fab.), *Chlaenius pusillus* Say, *Conoderus vespertinus* (Fab.), *C. rudis*, *Drasterius scutellatus* Schffr., larvae of *Chrysopa* sp., *Doru aculeatum* (Scudder), and different species of spiders. Photographs of some of these predators are presented in Plates 1-5. Photographs of some of their symptoms of feeding are presented in Plates 6-8.

The majority of these predators were observed feeding on eggs during the night. However, certain predators, i.e. imported-fire ant workers and larvae of *Chrysopa* sp. were also observed attacking egg masses during the day. Few spiders were active during daylight.

The incidence of various arthropod predator groups observed feeding on eggs of the sugarcane borer is shown in Table XI. The highest record of feeding was that of spiders, followed by ants, click beetles, ground beetles, lacewings, and earwigs, in that order.

Examining the soil surface among sugarcane plants indicated that certain species of predators took shelter in the immediate vicinity of the plants and searched the cane plants only at night.

Table X. Arthropod predators observed preying on the sugarcane borer and life stages preyed on, Napoleonville, Louisiana, June to September, 1966 and 1967.

	Stage or stages preyed on
Hymenoptera (Formicidae)	
Solenopsis saevissima richteri Forel	egg, larva, pupa
Coleoptera (Carabidae)	
Leptotrachelus dorsalis (Fab.)	egg
Chlaenius pusillus Say	egg
Harpalus sp.	larva
Elateridae	
Conoderus vespertinus (Fab.)	egg, larva
C. rudis Brown	egg
Drasterius scutellatus Schffr.	egg
Neuroptera (Chrysopidae)	
Chrysopa sp.	egg
Dermaptera	
Doru aculeatum (Scudder)	egg
Anisolabis annulipes (Lucas)	larva
Araneida	
Eperigone tridentata Emerton	egg
Pardosa milvina (Hentz)	egg
Singa variabilis Emerton	egg, larva
Achaearanea index Chamberline and Ivie	egg
Coleosoma acutiventer Keyserling	egg
Paratheridula quadrimaculatus Banks	egg
Clubiona abotti L. Koch	egg, larva
Lycosa helluo Walck.	adult
Habronattus coronatus (Hentz)	egg

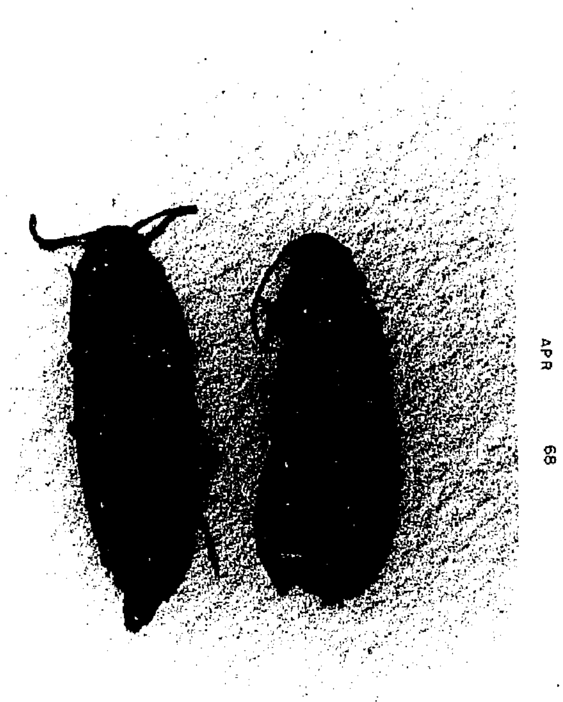

Plate 1. Adult <u>Conoderus</u> <u>rudis</u> Brown

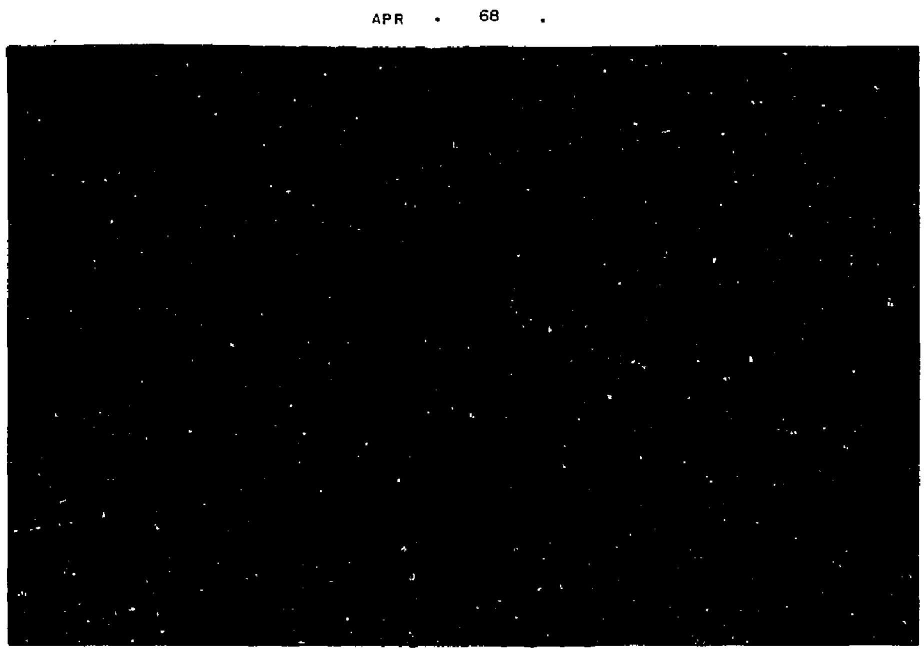

Plate 2. Adult Leptotrachelus dorsalis (Fab.)

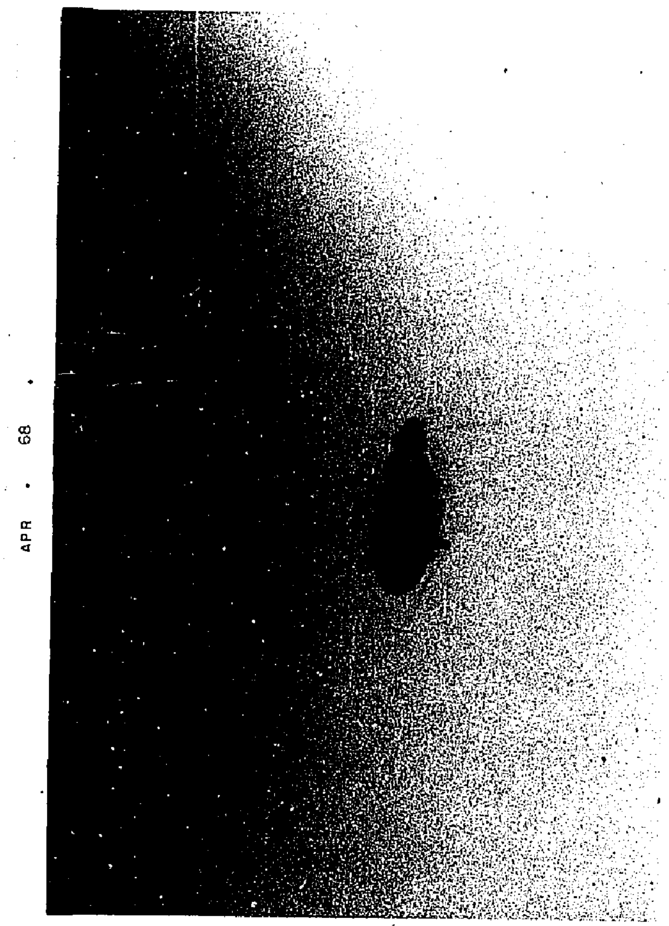

Plate 3. Adult <u>Chlaenius pusillus</u> (Say)

Plate 4. Larvae of Chrysopa sp.

Plate 5. Larvae of <u>Harpalus</u> sp.

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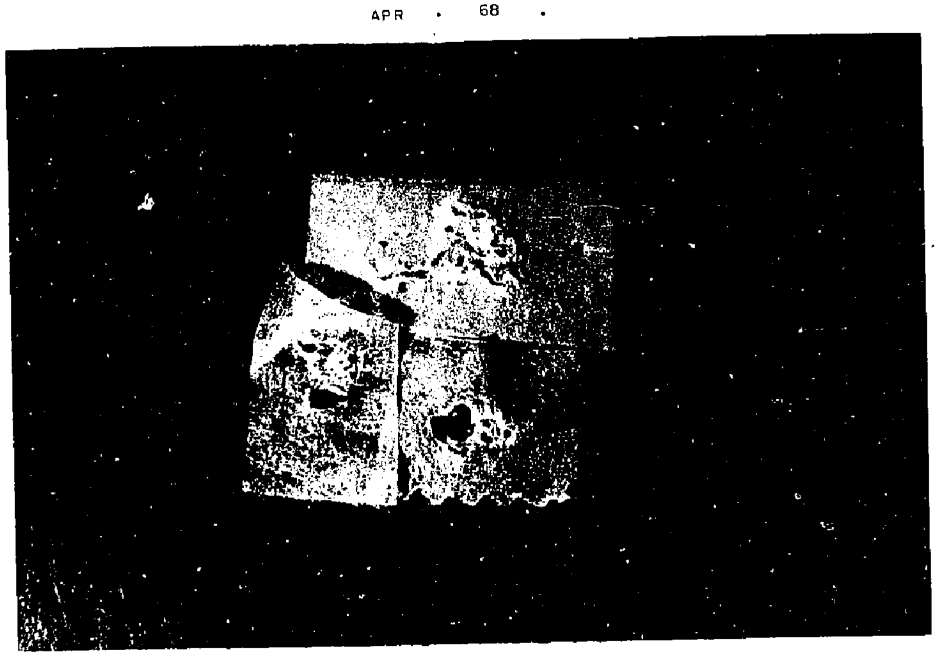

Plates 6 and 7. Symptoms of feeding by chewing predators.

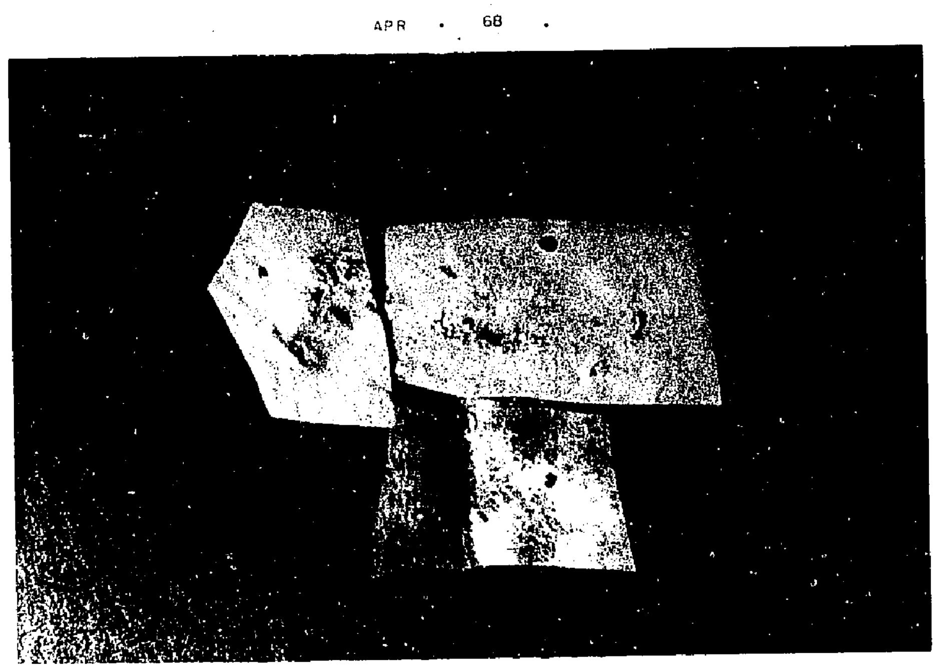

Plate 8. Symptoms of feeding by sucking predators.

Table XI. Number of incidents of various arthropod predatory groups that were observed feeding on sugarcane borer egg masses, June to September, Napoleonville, Louisiana, 1967.

Trial No.	Araneida*	Carabidae*	Elateridae*	Forficulidae*	Formicidae**	Chrysopidae**
1	2.0	0.0	1.0	0.0	0.0	0.0
2	1.0	0.0	0.0	0.0	0.0	0.0
3	0.0	1.0	1.0	0.0	3.0	0.0
4	3.0	2.0	0.0	1.0	2.0	0.0
5	4.0	1.0	2.0	0.0	1.0	1.0
6	3.0	0.0	0.0	1.0	1.0	2.0
7	2.0	0.0	1.0	0.0	2.0	0.0
8	2.0	0.0	0.0	0.0	1.0	1.0
Total	17.0	4.0	5.0	2.0	10.0	4.0

*During night.
**During day.

It was found that not all species of carabids have the ability to forage for prey on sugarcane plants. The majority of carabid species frequented the soil surface at night. Elaterid species were frequently observed on the sugarcane plants as were also some species of carabids (Table I).

Predators appeared to find egg masses by random searching rather than by positive searching behavior. However, in the case of the imported-fire ant, the initial finding of an egg mass appeared to stimulate further searching within a restricted area.

Symptoms of feeding on egg masses were generally classified as those of sucking predators (spiders and chrysopid larvae) and those of chewing predators (ground beetles, click beetles, and earwigs). Egg masses fed upon by chewing predators were eaten with part of the waxed paper in an irregular manner (Plates 6, 7). Imported-fire ant workers were observed cutting egg masses into smaller portions and each individual or group of individuals carried a part of the egg mass to the mound. In most cases, the whole egg mass was eaten by a specific predator and only in a few occasions were they partially fed upon.

Eggs fed upon by spiders and chrysopid larvae became collapsed and shrunken and the feeding of these sucking arthropods caused no injury to the waxed paper on which the eggs were deposited (Plate 8). Overlapping between the different symptoms of feeding was noticed and for this reason, it was difficult to associate a certain symptom with a specific predator. Undoubtedly, more than one predator may attack the same egg mass.

Larvae of Chrysopa sp. did not detect the presence of the sugarcane borer eggs until they came in contact with it. These larvae covered themselves with pieces of trash, exuvia or other debris that appears to be cemented together (Plate 4). The body of a larva is completely covered with these materials and is not readily visible unless the larva is moving. These larvae were always found on sugarcane leaves.

Many species of spiders regularly inhabit sugarcane plants. Individuals of some species were seldom collected from the sugarcane plants but were found on the ground under plants. Clubiona abotti lives on sugarcane foliage or grasses where they construct tubular webs in rolled up leaves. Habronattus coronatus was found on both sugarcane foliage and on the ground. Most species of Lycosidae are ground dwellers, and this was one of the most prevalent of all spider families found in the sugarcane field under study. Many species of Lycosidae are active at night and also during daylight hours. This group of spiders were very abundant in the grassy plots of sugarcane.

The predator species studied in the laboratory were: larvae of Chrysopa sp.; the elaterid beetle, Conoderus vespertinus; the carabid, Chlaenius pusillus; and the earwig, Doru aculeatum. Within a relatively short time each predator fed upon sugarcane borer eggs when confined in vials with them.

Larval Mortality

Larval predation and behavior

Table XII shows a summary of averages of percent recovery of the sugarcane borer larvae during June and July in both 1966 and in 1967.

Table XII. Summary of averages of percent recovery of sugarcane borer larvae in heptachlor-treated, and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.[1]

Interval between hatching & recovery (weeks)	1966				1967			
	June		July		June		July	
	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.
1	4.6	1.9	6.6	5.3	16.2	1.4	13.1	15.8
2	1.5	0.0	3.9	6.0	3.8	11.3	4.3	3.0
3	2.1	1.4	8.6	3.9	3.5	1.2	9.4	8.8
4	6.3	5.3	7.1	7.5	4.9	2.4	12.8	9.9
Average	3.6	4.3	6.6	5.7	7.1	4.1	9.9	9.1

[1]Each figure represents a mean of 20 counts. Data are shown in Table XXX in the appendix.

1966: Treatments (ns); Months (**); Treatments x Months (ns).
1967: Treatments (ns); Months (**); Treatments x Months (ns).

Data in this table are illustrated graphically in Figure 6. No significant difference in percent larval recovery was found between treatments. Also, there was no significant interaction between treatments and months. A significant difference in percent recovery was found between months. Generally, percent larval recovery was higher in July than in June.

Table XIII shows percentages of sugarcane plants that had fresh sugarcane borer symptoms of feeding indicating recent borer infestation, yet no larvae were present in the leaf sheaths of the plants. A significant difference in percentages of these plants was found between treatments and also from month to month. Percentages of such plants increased from June to August.

Table XIV shows that numbers of Harpalus larvae, a predator of early stages of sugarcane borer larvae, do not differ significantly between treatments. A slight increase in numbers of predator larvae was present on plants recorded from month to month.

Table XV shows partial regression coefficients of percentages of hatchability of borer eggs, numbers of predators, or numbers of sugarcane plants per stool on percentages of larval recovery. It was found that numbers of predators and percentages of hatchability have a more significant effect on percentages of larval recovery than numbers of plants per stool.

Studying the behavior of sugarcane borer larvae after hatching revealed that they moved at random but the majority of them oriented towards the leaf sheaths of the plants. The larvae which proceeded toward the tip of the cane leaves wander actively and may pass directly onto other plants by means of interlocking leaves, or lower themselves

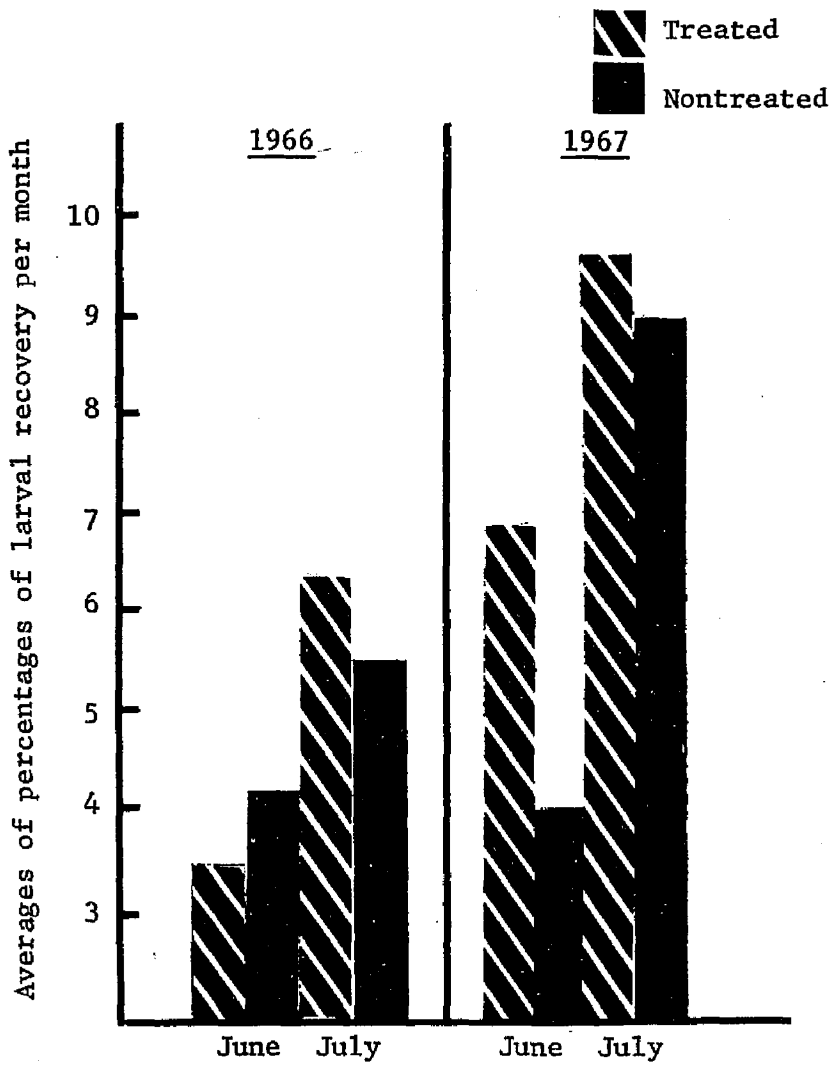

Figure 6. Averages of percentages of larval recovery in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.

Table XIII. Percentages of sugarcane plants in treated and nontreated plots that had fresh symptoms of feeding and no larvae present in leaf sheaths. Napoleonville, Louisiana, 1966.[1]

Replicate	Treated			Nontreated		
	June	July	August	June	July	August
1	20.0	20.0	10.0	30.0	20.0	50.0
2	30.0	40.0	30.0	10.0	40.0	30.0
3	40.0	20.0	40.0	20.0	40.0	40.0
4	10.0	10.0	40.0	10.0	30.0	60.0
Average	25.0	22.5	30.0	17.5	32.5	45.0

[1]Percentages were based on 10 sugarcane stalk-sample per replicate.
Treatments (*)
Months (*)
Treatment x Months (*)

Table XIV. Numbers of *Harpalus* larvae collected from 10 sugarcane plants in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.[1]

Replicate	Treated			Nontreated		
	June	July	August	June	July	August
1	2.0	3.0	2.0	2.0	4.0	5.0
2	1.0	2.0	3.0	2.0	4.0	4.0
3	1.0	1.0	1.0	2.0	3.0	3.0
4	0.0	0.0	3.0	1.0	3.0	4.0
Average	1.0	1.5	2.3	1.8	3.5	4.0

[1]One sample was collected each month.
Treatments (ns)
Months (*)
Treatments x Months (ns)

Table XV. Partial regression coefficients of percent hatchability, numbers of predators or numbers of sugarcane plants per stool on percent larval recovery, Napoleonville, Louisiana, 1966.

Criteria		Percent larval recovery (y) Partial regression coefficients (b)		
		$X_1X_2X_3$	X_1X_2	X_1
Percent hatchability	(X_1)	0.731**	0.734**	0.759*
No. of predators	(X_2)	7.934**	8.233**	---
No. of plants per stool	(X_3)	1.971 ns	---	---

Computation based on data in Table XXI in the appendix.

by slender threads to other leaves or may be blown away by light wind. Cannibalism was not observed among larvae.

Feeding behavior and habits of larval predators

Predators that were observed feeding on sugarcane borer larvae were: larvae of the carabid, *Harpalus* spp.; imported-fire ant workers, *Solenopsis saevissima richteri*, and certain species of spiders (Table X). The most important among these predators were the carabid larvae (Figure 5). During dissection of sugarcane plants it was noted that these larvae were associated with and always found behind the leaf sheaths of the infested plants and they were never recovered from plants showing no visible symptoms of infestation. These larvae were observed attacking 1st, 2nd, and 3rd instars of borer larvae during their feeding on the inner surface of the leaf sheaths. Larvae were very active and fed on the body fluids of the young sugarcane borer larvae. These larvae were considered most important because they attack the borer during the critical period of their establishment and early development on the sugarcane plants and this caused mortality before the larvae had matured sufficiently to cause plant damage.

Imported-fire ant workers were observed feeding on the young sugarcane borer larvae during and after hatching. However, the ability of the workers to feed on larvae behind the leaf sheaths was limited unless the leaf sheaths were loose enough to permit free passage of ants. In the damaged stalks of older sugarcane, ants were observed to attack full-grown larvae and pupae within tunnels.

Spiders were observed to capture 1st instar larvae of the sugarcane borer soon after hatching and while they were crawling about.

Sugarcane Borer Damage

Table XVI shows percentages of joints bored by the sugarcane borer in heptachlor-treated and nontreated plots in 1966 and in 1967. Percentages of joints bored were significantly higher in treated than nontreated plots. Percentages of joints bored were significantly higher in 1967 than in 1966.

Table XVI. Percentages of joints bored by the sugarcane borer in heptachlor-treated and nontreated plots, October, 1966 and 1967.

Treatments	Replicates 1	2	3	4	Average
			1966		
Heptachlor	19.1	12.9	19.8	18.0	17.5
Nontreated	3.8	3.6	5.5	4.3	4.3
			1967		
Heptachlor	45.8	45.4	26.6	41.4	39.8
Nontreated	25.0	31.6	22.4	33.0	28.0

1966: Treatments (**).
1967: Treatments (*).

DISCUSSION

Data obtained from this type of experimentation provided a correlation between populations of predatory arthropods and sugarcane borer populations from which the efficiencies of specific natural enemies can be inferred. The main objective of the use of insecticides in these experiments was to cause fluctuations in predator populations so that the corresponding effects on sugarcane borer populations could be measured.

This study attempted to evaluate the effects of predators on sugarcane borer populations by means of the single-factor analysis of mortality data. This approach is useful for certain species of economic importance which because of their behavior or habitat do not lend themselves to multi-factor analysis of mortality data.

The nature of the life cycle of the sugarcane borer, larval behavior, overlapping between different larval instars and generations, multiplicity of mortality factors and the complexity of their interrelations represent certain difficulties which preclude a thorough evaluation of mortality factors that affect each stage of the borer, especially the larval stages.

Data on the seasonal abundance of predator populations (Tables II and III) gave a qualitative indication of the period of their activity in the field and the relative abundance of each group of predators. No attempt was made to determine the absolute population density of individual species. These results show that predator populations built up gradually from June to September in the sugarcane field under study. It was not until August and September that populations of ants differed significantly between treatments (Table III).

The practice of controlling weeds by plowing or hoeing in the experimental plots may have had a disturbing effect on ant populations by destroying mounds early in the crop season.

The initial population level of spiders was relatively higher than ant populations early in the growing season. Data in Table III show that the average numbers of ants and spiders were less in heptachlor-treated than in nontrated plots. Moreover, the effectiveness of heptachlor treatments against spiders varied significantly from month to month. It seems that heptachlor is consistently more destructive to ants than spiders (Negm and Hensley, 1967). Spider populations, during certain months of the year, may be equally abundant in the treated and nontreated plots. This was realized in 1967 where no significant difference was found in total numbers of predators or numbers of spiders between treatments.

Trap catches showed that predator populations were not evenly distributed among individual plots. Pitfall traps were generally considered a satisfactory trapping method for ants and spiders. This conclusion was reached by continuous observations of ants and spiders as they approached the traps. However, it was realized that traps are not an efficient method for sampling all soil-inhabiting arthropods. For example, not all species of carabids were represented in the trap.catches. The numbers of each predator species caught depend on the degree of its activity, population density and the location. Catches in the traps varied with temperature, rain and other environmental factors. These factors, particularly rain, affected the activity of certain groups of predators, especially ants, and therefore the numbers that were caught in the traps. Ground cover is also important because it was found that grassy plots were inhabited by large numbers of certain species of arthropods, especially spiders.

Complete and permanent suppression of predator populations in the treated plots was difficult to achieve due to constant immigration of predators from the surrounding nontreated plots and probably due to the differential effect of heptachlor on different predator groups.

Data in Table IV showed that the highest percentages of egg predation were recorded during July, August and September in this particular area. This coincided with the predator population trend which increased gradually from June to September. Percentages of predation have their own significance only at times and places where samples were taken. The numbers of eggs eaten by individual predators could never be assumed to be a constant value. Changing environmental conditions may have had a marked effect on the interaction between predator and prey.

Results in Tables V and VI, showed that sucking predators were more important than chewing predators as control agents of sugarcane borer eggs. Since spider populations were more abundant than ant populations (Table III) and constituted the major component of sucking predators, it was concluded that spiders are relatively more important than ants as egg predators. This was supported by the significant correlation coefficients obtained between numbers of spiders and percentages of egg predation and the nonsignificant correlation coefficients between numbers of ants and percentages of egg predation (Table IX).

The relative importance of each group of predators may vary with the time of the year, population density and locality. Negm and Hensley (1967) reported that ant populations were relatively higher and therefore more important than spider populations as predators of the sugarcane borer in an experiment conducted at Cinclare Plantation, Port Allen, Louisiana.

Higher percentages of egg predation were recorded during darkness than daylight hours, because most of the predatory species were nocturnal in habits. However, during July, August, and September, some predation was recorded during daylight (Table VII). This predation coincided with the appearance of certain diurnal predators, especially the larvae of *Chrysopa* sp.

The most critical period for the survival of the sugarcane borer larvae is during the early stages in the life cycle of the pest before they start boring either in the leaf sheaths or in the stems of the plants. During this period the young larvae exposed on leaves or in sheaths are vulnerable to attack by certain predators as well as to the adverse effects of direct weather factors. Variety of cane and the stage of cane growth may also affect percentages of larval recovery and the degree of larval establishment. It was realized that not all losses in larval populations could be considered as a result of direct mortality factors. Young newly hatched larvae have been observed to be carried by air currents to other plants. Larval dispersion by this means was not considered to be an absolute mortality factor.

It served mainly to redistribute larval population, especially late in the growing season. As a result of this, the actual values of percentages of larval recovery may be slightly higher than the estimated values (Table XII).

Although percentages of hatchability of borer eggs was found to influence the degree of larval recovery, this relationship may not be linear and the interplay of other factors, especially weather, may alter or modify it.

In 1967 borer populations were higher than in 1966. This corresponded with low predator populations and higher percentages of larval recovery. Increases of infestations in heptachlor treated plots were probably due to suppression of populations of predators (Hensley et al., 1961; Negm and Hensley, 1967).

CONCLUSIONS

1. Predator populations built up gradually from June to September in the sugarcane field under study. The relative abundance of ant and spider populations depended upon the time of the year, location and the cultural practices.

2. Heptachlor treatments may have a differential effect on the different groups of soil-inhabiting predaceous arthropod. It seems that this insecticide is consistently more destructive to ants than spiders.

3. Pitfall traps, as a sampling technique, were considered to be an efficient trapping method for ants and spiders. However, they were not considered to be a satisfactory method for sampling populations of all soil-inhabiting arthropods.

4. The highest percentage of sugarcane borer eggs destroyed by arthropod predators was recorded during July, August, and September. Sucking predators were found to be more important than chewing predators in this respect. It was found that spiders were more important than ants as biological control agents of sugarcane borer eggs.

5. Percent recovery of sugarcane borer larvae was higher in July than in June. Numbers of predators and percentages of hatachability have more significant effect on percent larval recovery than numbers of sugarcane plants per stool. Larval dispersion was not considered to be an absolute mortality factor. It served mainly to redistribute larval populations in the field, especially late

in the growing season and is considered beneficial to the species.

6. Percentages of predation are not constant values and are subject to fluctuations due to the multiplicity of the interacting factors that affect both the predators and the sugarcane borer.

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APPENDIX

Table XVII. Total number of predators collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.

	Treated				Untreated			
Replicate	June	July	Aug.	Sept.	June	July	Aug.	Sept.
				First Week				
1	5.0	6.0	4.0	13.0	4.0	5.0	19.0	21.0
2	4.0	2.0	4.0	10.0	4.0	5.0	11.0	19.0
3	3.0	3.0	3.0	10.0	5.0	4.0	10.0	14.0
4	4.0	4.0	3.0	9.0	6.0	12.0	7.0	29.0
Total	16.0	15.0	14.0	42.0	19.0	26.0	37.0	83.0
				Second Week				
1	6.0	5.0	4.0	10.0	3.0	10.0	20.0	8.0
2	4.0	5.0	6.0	15.0	2.0	9.0	31.0	9.0
3	4.0	3.0	4.0	9.0	5.0	12.0	10.0	27.0
4	4.0	2.0	2.0	2.0	9.0	7.0	2.0	3.0
Total	18.0	15.0	16.0	36.0	19.0	38.0	63.0	47.0
				Third Week				
1	3.0	8.0	7.0	9.0	2.0	12.0	15.0	16.0
2	5.0	4.0	8.0	5.0	3.0	19.0	14.0	17.0
3	2.0	4.0	5.0	10.0	4.0	2.0	12.0	4.0
4	2.0	7.0	8.0	11.0	4.0	2.0	25.0	18.0
Total	12.0	23.0	28.0	35.0	13.0	35.0	66.0	45.0
				Fourth Week				
1	5.0	2.0	8.0	10.0	3.0	4.0	5.0	20.0
2	6.0	2.0	7.0	11.0	2.0	5.0	7.0	4.0
3	6.0	3.0	5.0	5.0	2.0	6.0	4.0	5.0
4	4.0	3.0	7.0	3.0	8.0	8.0	15.0	9.0
Total	21.0	10.0	27.0	29.0	15.0	23.0	31.0	38.0
Grand Total	67.0	63.0	85.0	142.0	66.0	122.0	197.0	213.0
Average	16.8	15.8	21.3	35.5	16.5	30.5	49.3	53.3

Table XVIII. Total number of predators collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1967.

	Treated				Nontreated			
Replicate	June	July	Aug.	Sept.	June	July	Aug.	Sept.
				First Week				
1	2.0	4.0	5.0	17.0	2.0	10.0	5.0	15.0
2	0.0	3.0	6.0	15.0	3.0	3.0	4.0	10.0
3	3.0	2.0	4.0	8.0	1.0	4.0	4.0	5.0
4	2.0	2.0	7.0	1.0	2.0	5.0	5.0	10.0
Total	7.0	11.0	22.0	41.0	8.0	22.0	18.0	40.0
				Second Week				
1	1.0	7.0	11.0	10.0	1.0	4.0	15.0	12.0
2	2.0	2.0	5.0	10.0	1.0	3.0	10.0	21.0
3	2.0	5.0	3.0	12.0	0.0	9.0	10.0	12.0
4	0.0	5.0	2.0	3.0	0.0	13.0	2.0	6.0
Total	5.0	19.0	21.0	35.0	2.0	29.0	27.0	51.0
				Third Week				
1	3.0	3.0	3.0	5.0	2.0	4.0	10.0	18.0
2	4.0	4.0	2.0	4.0	0.0	7.0	10.0	2.0
3	0.0	4.0	1.0	9.0	0.0	6.0	7.0	5.0
4	0.0	1.0	13.0	4.0	0.0	0.0	9.0	1.0
Total	7.0	12.0	19.0	22.0	2.0	17.0	36.0	26.0
				Fourth Week				
1	1.0	6.0	4.0	4.0	0.0	6.0	2.0	19.0
2	2.0	7.0	5.0	6.0	1.0	6.0	5.0	10.0
3	2.0	2.0	7.0	5.0	1.0	4.0	6.0	4.0
4	2.0	3.0	0.0	18.0	0.0	5.0	9.0	5.0
Total	7.0	18.0	16.0	33.0	2.0	21.0	22.0	38.0
Grand Total	26.0	60.0	78.0	131.0	14.0	89.0	113.0	155.0
Average	6.5	15.0	19.5	32.8	3.5	22.3	28.3	38.8

Table XIX. Total numbers of ants collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.[1]

	Treated				Nontreated			
Week	June	July	Aug.	Sept.	June	July	Aug.	Sept.
1	5.0	0.0	1.0	10.0	6.0	2.0	10.0	15.0
2	4.0	2.0	3.0	12.0	7.0	5.0	13.0	26.0
3	2.0	4.0	10.0	17.0	2.0	4.0	16.0	15.0
4	6.0	2.0	15.0	18.0	1.0	1.0	12.0	20.0
Total	17.0	8.0	29.0	57.0	16.0	12.0	51.0	76.0

Table XX. Total numbers of ants collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1967.[1]

	Treated				Nontreated			
Week	June	July	Aug.	Sept.	June	July	Aug.	Sept.
1	2.0	0.0	6.0	10.0	3.0	10.0	6.0	19.0
2	1.0	3.0	1.0	10.0	0.0	5.0	5.0	18.0
3	3.0	2.0	5.0	10.0	0.0	11.0	15.0	11.0
4	0.0	5.0	4.0	18.0	1.0	4.0	10.0	23.0
Total	6.0	10.0	17.0	48.0	4.0	30.0	36.0	71.0

[1]Figures are totals of 4 replicates.

Table XXI. Total numbers of spiders collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.[1]

	Treated				Nontreated			
Week	June	July	Aug.	Sept.	June	July	Aug.	Sept.
1	11.0	12.0	13.0	31.0	12.0	21.0	24.0	65.0
2	13.0	12.0	12.0	22.0	10.0	29.0	48.0	19.0
3	10.0	17.0	16.0	12.0	11.0	31.0	49.0	23.0
4	15.0	7.0	10.0	9.0	12.0	19.0	18.0	17.0
Total	49.0	48.0	51.0	74.0	45.0	100.0	139.0	124.0

Table XXII. Total numbers of spiders collected in pitfall traps in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1967.[1]

	Treated				Nontreated			
Week	June	July	Aug.	Sept.	June	July	Aug.	Sept.
1	5.0	10.0	15.0	30.0	4.0	10.0	10.0	20.0
2	3.0	15.0	20.0	10.0	2.0	20.0	30.0	30.0
3	4.0	10.0	13.0	10.0	1.0	5.0	20.0	11.0
4	5.0	11.0	10.0	14.0	1.0	16.0	9.0	10.0
Total	17.0	46.0	58.0	64.0	8.0	51.0	69.0	71.0

[1]Figures are total of 4 replicates.

Table XXIII. Percent predation of sugarcane borer egg masses destroyed by arthropod predators in heptachlor-treated and non-treated plots, Napoleonville, Louisiana, 1966.

Replicate	Treated				Nontreated			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.
				First Week				
1	10.0	0.0	30.0	50.0	40.0	80.0	60.0	60.0
2	20.0	10.0	40.0	30.0	40.0	60.0	70.0	70.0
3	10.0	30.0	40.0	50.0	40.0	70.0	70.0	60.0
4	20.0	40.0	50.0	40.0	40.0	70.0	60.0	70.0
Av.	15.0	20.0	40.0	42.5	40.0	70.0	65.0	65.0
				Second Week				
1	20.0	10.0	40.0	30.0	70.0	50.0	60.0	50.0
2	20.0	20.0	50.0	20.0	50.0	60.0	80.0	80.0
3	30.0	40.0	60.0	40.0	60.0	70.0	70.0	50.0
4	30.0	40.0	40.0	50.0	30.0	70.0	60.0	50.0
Av.	25.0	27.5	47.5	35.0	52.5	62.5	67.5	57.5
				Third Week				
1	30.0	30.0	40.0	40.0	50.0	50.0	70.0	60.0
2	40.0	40.0	30.0	60.0	40.0	40.0	80.0	70.0
3	10.0	40.0	40.0	70.0	30.0	70.0	80.0	80.0
4	40.0	50.0	40.0	40.0	50.0	60.0	90.0	50.0
Av.	30.0	37.5	37.5	60.0	42.5	55.0	80.0	65.0
				Fourth Week				
1	40.0	30.0	40.0	30.0	50.0	50.0	70.0	50.0
2	40.0	50.0	50.0	50.0	50.0	50.0	60.0	60.0
3	30.0	60.0	60.0	20.0	40.0	60.0	90.0	50.0
4	20.0	70.0	50.0	40.0	50.0	70.0	80.0	70.0
Av.	32.5	52.5	50.0	35.0	47.5	57.5	75.0	57.5
Grand Av.	25.6	34.4	43.8	41.3	45.6	61.3	71.9	61.3

Table XXIV. Percent predation of sugarcane borer egg masses destroyed by arthropod predators, in heptachlor-treated and non-treated plots, Napoleonville, Louisiana, 1967.

Replicate	Treated				Nontreated			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.
				First Week				
1	0.0	20.0	30.0	40.0	30.0	20.0	50.0	40.0
2	10.0	0.0	20.0	50.0	20.0	20.0	60.0	30.0
3	10.0	0.0	10.0	30.0	30.0	40.0	70.0	60.0
4	0.0	10.0	50.0	20.0	20.0	50.0	90.0	70.0
Av.	5.0	7.5	27.5	35.0	25.0	32.5	67.5	50.0
				Second Week				
1	20.0	30.0	20.0	30.0	40.0	30.0	40.0	40.0
2	10.0	40.0	50.0	20.0	20.0	40.0	50.0	80.0
3	10.0	20.0	50.0	30.0	20.0	40.0	70.0	70.0
4	20.0	40.0	40.0	20.0	30.0	10.0	80.0	60.0
Av.	15.0	32.5	40.0	25.0	27.5	30.0	60.0	62.5
				Third Week				
1	20.0	30.0	10.0	30.0	30.0	40.0	30.0	40.0
2	30.0	20.0	0.0	30.0	20.0	20.0	40.0	50.0
3	0.0	60.0	30.0	20.0	20.0	10.0	50.0	70.0
4	20.0	0.0	40.0	10.0	10.0	70.0	60.0	60.0
Av.	17.5	27.5	20.0	22.5	20.0	35.0	35.0	55.0
				Fourth Week				
1	20.0	40.0	40.0	20.0	40.0	40.0	70.0	50.0
2	30.0	40.0	50.0	30.0	40.0	60.0	80.0	60.0
3	30.0	50.0	70.0	40.0	50.0	70.0	60.0	70.0
4	20.0	60.0	70.0	20.0	60.0	80.0	60.0	70.0
Av.	25.0	47.5	57.5	27.5	47.5	62.5	67.5	62.5
Grand Av.	15.6	28.8	36.3	27.5	30.0	40.0	60.0	57.5

Table XXV. Comparison between percentage of egg masses destroyed by sucking and chewing predators in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.[1]

Month/weeks	Treated Sucking Predators	Treated Chewing Predators	Nontreated Sucking Predators	Nontreated Chewing Predators
June				
I	10.0	5.0	30.0	10.0
II	20.0	5.0	50.0	2.5
III	30.0	0.0	32.5	10.0
IV	30.0	2.5	40.0	7.5
Av.	22.5	3.1	38.1	7.5
July				
I	10.0	10.0	50.0	20.0
II	10.0	17.5	45.0	17.5
III	30.0	7.5	20.0	35.0
IV	25.0	27.5	25.0	32.5
Av.	18.8	15.6	35.0	26.3
August				
I	30.0	10.0	60.0	5.0
II	17.5	30.0	50.0	17.5
III	30.0	7.5	40.0	40.0
IV	25.0	25.0	50.0	25.0
Av.	25.6	18.2	50.0	21.9
September				
I	20.0	22.5	40.0	25.0
II	25.0	10.0	35.0	22.5
III	40.0	20.0	40.0	25.0
IV	30.0	5.0	20.0	37.5
Av.	28.7	14.4	33.8	27.5
Grand Av.	23.9	12.8	39.2	20.8

[1]Figures are averages of 4 replicates.

Table XXVI. Comparison between percentage of egg masses destroyed by sucking and chewing predators in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1967.[1]

Month/weeks	Treated Sucking Predators	Treated Chewing Predators	Nontreated Sucking Predators	Nontreated Chewing Predators
June				
I	5.0	0.0	15.0	16.0
II	10.0	5.0	15.0	12.5
III	15.0	2.5	20.0	0.0
IV	5.0	20.0	35.0	12.5
Av.	8.8	6.8	21.3	8.7
July				
I	7.5	0.0	20.0	12.5
II	27.4	5.0	30.0	0.0
III	7.5	20.0	25.0	10.0
IV	30.0	17.5	40.0	22.5
Av.	18.2	16.6	28.7	11.3
August				
I	10.0	17.5	50.0	17.5
II	30.0	10.0	40.0	20.0
III	10.0	10.0	40.0	5.0
IV	40.0	17.5	45.0	22.5
Av.	22.5	13.8	43.7	16.3
September				
I	25.0	10.0	40.0	10.0
II	15.0	10.0	60.0	2.5
III	2.5	20.0	30.0	25.0
IV	20.0	7.5	40.0	22.5
Av.	15.6	11.9	42.5	15.0
Grand Av.	16.3	10.8	34.1	12.8

[1]Figures are averages of 4 replicates.

Table XXVII. Percent predation of the sugarcane borer egg masses preyed upon by arthropod predators during daylight and darkness hours, Napoleonville, Louisiana, 1966.

	Treated		Nontreated	
	Period of exposure (12 hrs.)			
Month/count	Daylight	Darkness	Daylight	Darkness
June				
I	0.0	10.0	0.0	15.5
II	0.0	0.0	0.0	20.0
III	0.0	22.5	0.0	10.0
IV	0.0	12.5	0.0	5.0
Av.	0.0	11.3	0.0	12.6
July				
I	5.0	0.0	5.0	5.0
II	0.0	15.0	17.5	0.0
III	0.0	12.3	5.0	0.0
IV	0.0	10.0	0.0	25.0
Av.	1.3	9.3	6.9	7.5
August				
I	10.0	25.0	0.0	17.5
II	0.0	0.0	0.0	15.5
III	0.0	7.5	0.0	0.0
IV	0.0	17.5	0.0	5.0
Av.	2.5	12.5	0.0	9.5
September				
I	10.0	0.0	12.3	17.5
II	10.0	5.0	0.0	12.3
III	0.0	17.5	0.0	20.0
IV	0.0	20.0	5.0	30.0
Av.	5.0	10.6	4.3	19.9
Grand Av.	2.2	10.9	2.8	12.4

Table XXVIII. Average numbers of total predator complex, ants, and spiders, and number of egg masses destroyed by arthropod predators in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966.

Weeks	No. Predator Complex		No. Ants		No. Spiders		Av. No. Egg Masses Destroyed	
	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.
1	4.0	4.8	1.3	1.5	3.8	4.0	1.5	4.0
2	4.5	4.8	1.0	1.8	3.3	2.5	2.5	5.3
3	3.0	3.3	0.5	0.5	2.5	2.8	3.0	4.3
4	5.3	3.8	1.5	0.3	3.8	3.0	3.3	4.8
5	3.8	6.5	0.0	0.5	3.0	5.3	2.0	7.0
6	3.8	9.5	6.5	1.3	3.0	7.3	2.8	6.3
7	5.8	8.8	1.0	1.0	4.3	7.8	3.8	5.5
8	2.5	5.8	0.5	0.3	1.8	4.8	5.3	5.8
9	3.5	9.3	0.3	2.5	3.3	6.0	4.0	6.5
10	4.0	15.8	0.8	3.3	3.0	12.0	4.8	6.8
11	7.0	16.5	2.5	4.0	4.0	12.3	3.8	8.0
12	6.8	7.8	3.8	3.0	2.5	4.5	5.0	7.5
13	10.5	20.8	2.5	3.8	7.8	16.3	4.3	6.5
14	9.0	11.8	3.0	6.5	5.5	4.8	6.0	5.8
15	8.8	11.3	4.3	3.8	3.0	5.8	3.5	6.5
16	7.8	12.3	2.5	6.3	5.3	6.0	0.0	5.7
Av.	5.6	9.6	1.6	2.5	3.7	6.5	3.5	6.0

Table XXIX. Average numbers of total predators complex, ants, and spiders, and numbers of egg masses destroyed by arthropod predators, Napoleonville, Louisiana, 1967.

Weeks	No. Predators		No. Ants		No. Spiders		Av. No. Eggs Destroyed	
	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.
1	1.8	2.0	0.5	0.8	1.3	1.0	0.5	2.5
2	1.3	0.5	0.3	0.0	0.8	0.5	1.5	2.8
3	1.8	0.5	0.8	0.0	1.0	0.3	1.8	2.0
4	1.3	0.5	0.0	0.3	1.3	0.3	2.5	0.8
5	2.8	5.5	0.0	2.5	2.5	2.5	0.8	3.3
6	4.8	3.3	0.8	1.3	3.8	5.0	3.3	3.0
7	3.0	4.3	0.5	2.8	2.5	1.3	2.8	3.5
8	4.5	5.3	1.3	1.0	2.8	4.0	4.8	6.3
9	5.5	4.5	1.5	1.5	3.8	2.5	2.8	6.8
10	5.3	9.3	0.3	1.3	5.0	7.5	4.0	6.0
11	4.8	9.0	1.3	3.8	3.3	5.0	2.0	4.5
12	4.0	5.5	1.0	2.5	2.5	2.3	5.8	6.8
13	10.3	10.0	2.5	4.8	7.5	5.0	2.5	5.0
14	8.8	12.8	2.5	4.5	2.5	7.5	2.5	6.3
15	5.5	6.5	2.5	2.8	2.5	2.8	2.3	5.5
16	8.3	4.5	4.5	5.8	3.5	2.5	2.8	6.3
Av.	4.6	5.6	1.3	2.2	2.9	3.1	2.7	4.7

Table XXX. Average percent recovery of the sugarcane borer larvae during June and July in heptachlor-treated and nontreated plots, Napoleonville, Louisiana, 1966 and 1967.[1]

Interval between hatching and recovery	Treated: Av. no. of larvae hatched per stool	Treated: Av. no. of larvae recovered per stool	Treated: Av. % recovery	Nontreated: Av. no. of larvae per stool	Nontreated: Av. no. of larvae recovered per stool	Nontreated: Av. % recovery
			June 1966			
1 week	21.7	1.0	4.6	20.8	0.4	1.9
2 weeks	17.6	0.5	1.5	24.8	0.0	0.0
3 weeks	23.4	0.5	2.1	20.8	0.3	1.4
4 weeks	23.8	1.5	6.3	26.4	1.4	5.3
Average	21.6	0.9	3.6	23.2	0.5	4.3
			July 1966			
1 week	30.1	2.0	6.6	20.9	1.1	5.3
2 weeks	25.6	1.0	3.9	24.8	1.5	6.0
3 weeks	35.0	3.0	8.6	20.7	0.8	3.9
4 weeks	21.1	1.5	7.1	26.4	2.0	7.5
Average	27.9	1.8	6.6	23.2	1.4	5.7
			June 1967			
1 week	18.5	3.0	16.2	14.0	0.2	1.4
2 weeks	34.0	1.3	3.8	15.0	1.7	11.3
3 weeks	20.0	0.7	3.5	33.2	0.4	1.2
4 weeks	41.0	2.0	4.9	20.6	0.5	2.4
Average	28.4	1.7	7.1	20.7	0.7	4.1
			July 1967			
1 week	30.5	4.0	13.1	19.0	3.0	15.8
2 weeks	25.4	1.1	4.3	25.0	0.5	2.0
3 weeks	23.4	2.2	9.4	24.0	2.1	8.8
4 weeks	19.5	2.5	12.8	30.1	3.0	9.9
Average	24.7	2.5	9.9	24.5	2.2	9.1

[1]Each figure is an average of 20 counts.

Table XXXI. Percent hatch, percent larval recovery, number of predators and size (number of plants) in heptachlor-treated and non-treated plots in a sugarcane field, Bayou Sec, Napoleonville, Louisiana, 1966.

	Percent[a] hatch		Percent[a] recovery		Number of[b] predators		Stool size (no. of plants)	
Replicate	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.	Tr.	Nontr.
1	16.7	11.8	8.8	8.8	4.0	4.8	8.3	9.5
2	66.7	22.2	34.5	11.1	4.5	4.8	10.5	8.5
3	62.5	15.4	45.6	12.5	3.0	3.3	12.0	9.4
4	86.4	25.0	56.7	16.1	5.3	3.8	15.4	11.0
5	95.0	44.4	71.5	25.0	3.8	6.5	14.0	12.0
6	79.2	28.6	41.7	21.5	3.8	9.5	9.2	14.0
7	90.0	27.3	50.0	25.8	5.8	8.8	9.8	16.0
8	63.3	53.8	35.6	20.0	2.5	5.8	11.5	15.0
9	47.4	78.3	25.5	33.4	3.5	9.3	8.8	14.0
10	86.7	92.3	70.5	75.0	4.0	15.8	9.0	10.0
11	95.7	13.3	88.5	10.5	7.0	16.5	15.0	15.4
12	18.2	73.3	11.2	44.4	6.8	7.8	7.0	10.0
13	40.0	94.1	21.7	78.5	10.5	20.8	10.0	12.0
14	66.8	94.0	55.5	95.0	9.0	11.8	15.0	11.0
15	62.5	92.4	40.4	50.0	8.8	11.3	10.0	12.0
16	50.6	60.0	30.2	40.0	7.8	12.3	9.5	11.0
Av.	64.2	51.6	42.9	35.5	5.6	9.6	10.9	11.9

[a]Percent hatch and recovery were recorded after 24 hrs.

[b]Average number of predators per trap per week.

VITA

Ahmed Abdel Ghany Negm was born Novermber 30, 1938, at Cario, Egypt, United Arab Republic. He was graduated from Ismailia High School at Cairo in 1957.

From September 1957 to June 1961, he attended Cairo University, College of Agriculture, where he received the degree of Bachelor of Science in Entomology and Plant Päthölogy (Department of Plant Protection).

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EXAMINATION AND THESIS REPORT

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Major Field: Entomology

Title of Thesis: Ecological Studies of Certain Natural Mortality Factors of the Sugarcane Borer, Diatraea saccharalis (F.) in Louisiana

Approved:

S. D. Hensley

Major Professor and Chairman

Max Goodrich

Dean of the Graduate School

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Date of Examination:

May 7, 1968